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A Share in the things we stand for

When one of our old-timers retired recently from Standard Stations in West Los Angeles, fellow employees "wrote him up" thus:

"He has probably been nice to more people in Westwood Village than any other single person."

We'd like to tell you one or two inside reasons why such a man could know that inner glow you always find in people who make a career of "being nice to people."

From the day this Standard Oiler came to us — August 1, 1918, and the end of World War I was in the offing — he worked in a place congenial to his nature.

For 28 years or so he did his job, he made friends for himself and his company, he drew his pay regularly — and all the time he was building up credit in the retirement fund, and was saving some besides. These things combined to give him a feeling of security, a sense of well being.

So today he is retired, with a check coming in once a month to help meet the grocer's bill and the other bills that stubbornly come to all with the sureness of taxes.

Each month some of our old-timers reach the golfing years — the years for relaxing, fishing, *fun*. Then it is that their retirement benefits begin to pay off, for many build up enough retirement credit to foot not just some of the bills, but all of them.

No less important than the immediate advantages has been the knowledge that retirement age would *mean* retirement — not "the shelf." These people have spent a business lifetime without apprehension about the morrow.

STANDARD OF CALIFORNIA

The Course of Oil

by K. C. SCLATER

PRECEPTS IN FOREIGN OPERATIONS

Whether or not the oil industry of the United States has reached its zenith is a moot question. It does appear, however, that the domestic industry is in a period of lessening opportunity for American oil men; but there is opportunity abroad, and the American oil man is trained and prepared to take such opportunity. It is in the national interest that he does so. Thus, in effect, spoke E. DeGolyer at the Southwestern District Spring Meeting, Division of Production, American Petroleum Institute, at Shreveport, Louisiana.

"American companies are substantial and successful operators in foreign fields." On the whole, "foreign operations by Americans are strictly big-company operations. This is understandable. Foreign operations are generally slow and expensive. They involve difficulties beyond those common to domestic operations. Even markets, so simple at home as to present no substantial problem, may in case of successful foreign operations, involve the construction of pipe lines and even refineries." Such difficulties explain why foreign operations require greater amounts of capital than are necessary for domestic operations.

"There is at present a tendency for increasing numbers of smaller companies to operate in foreign areas and there is no reason why individuals or smaller companies, individually or in groups, should not engage in foreign operations."

One must weigh the political risk. "Consider the stability of government, economic conditions, legal concepts, and reckon with increasing tendencies toward nationalization. Consider alliances, foreign alignments, and outside pressures. Most of all, consider the people of the country. If you do not like them and if you cannot get along under their institutions as they exist, you had better stay out of the country."

Land tenure must be given important consideration. "In most foreign areas the subsoil pertains in some form or other to the state. The taking of leases — concessions, they are generally called — under such conditions is generally by either of two distinct procedures, both as to time and place.

"In some areas the nation either has no mining law adequate to govern petroleum grants or has no adequate petroleum law, in which case any grant of oil rights has to be negotiated with the heads of government and ratified by its legislative bodies." Under this procedure there is almost no limit to the type of concession that may be worked out.

"The other and far more rational type of procedure is that of nations, far too few in number, with adequate mining or petroleum laws which provide for grants of adequate size through some fixed and limited type of procedure."

In regard to diplomatic protection, "it cannot be emphasized too strongly that an American going into foreign country goes in on a parity with the nationals of that country; that his redress for any injustice he may suffer is through the courts of the country."

In general, "operations in foreign lands may be and often are subject to difficulties of which the average independent operating only in the United States finds it hard to even conceive. This is more nearly true for exploratory operations than it is for development operations, once a field has been found. Geologic work may have to be done on foot or horseback. The road to a drilling location may cost more than the well. Operations, especially of an exploratory nature, are subject to long delays. Replacement material for broken parts may have to be ordered from overseas."

There is also the problem of personnel. "Any initial operation by Americans in a foreign field is likely to be of an exploratory nature. It is natural that such ventures should be handled by Americans, but it is highly desirable, in case of success and long-continuing operations, that nationals of the country in which the operation is conducted be trained to replace Americans in every possible job, including the higher administrative posts, for which capable men can be found."

Important to remember is that "operations in a foreign field, aside from presenting you with a wider economic opportunity, are important to your Nation and to the nationals of the country in which you operate."

Foreign operations, if they are to prosper, "must be of definite and tangible benefit to the people of the nation in which you operate. I do not mean by this, to the people collectively — such as attained, for example, by the payment of royalty to their government. I mean, to as many of the people individually as your operations may be able to benefit. I know of one company operating in a foreign field which budgets and spends a definite and substantial sum per barrel of oil produced to improve the economy of the people among whom it works. It goes in for projects as far afield from the normal scope of its enterprise as agricultural improvements—irrigation schemes, improvement of animal breeding, etc. Does this sound altruistic? The hard-headed men who run the enterprise think it makes sense."

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Scanning WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—Development of a national oil policy, to assure adequate supplies from domestic sources and accessible foreign areas, will be under auspices of civilian authorities rather than the military.

This decisive step was taken by President Truman when he requested Interior Secretary Krug to coordinate all federal oil and gas activities and to act as the "channel of communication" between the petroleum industry and all governmental agencies, and vice versa.

Krug's first move was to establish a new oil and gas division in the Interior Department. Next he began negotiations with the Department of Justice for a "green light" on appointment of an industry advisory committee, as suggested by Truman. This group, to be known as the National Petroleum Council, will be as large as the Petroleum Industry War Council was, with membership much the same. With a total of 70 to 80 members, there is ample room for the NPC to be completely representative of all elements in all branches. An executive committee may be set up, chosen from membership of the council.

Besides the national council, there probably will be subcommittees on production, refining, natural gas, marketing, economics, etc. Membership probably will not be restricted to those on the council, but will include representative oil men from all over the country. Thus, still greater opportunity will be provided for making the council setup representative, geographically as well as by groups.

Ralph K. Davies, deputy administrator of PAW, which was folded on May 8, is staying on—at the suggestion of the President—to organize the new setup for government-industry cooperation on oil matters.

Interior's new oil and gas division was not set up under any statute, but by administrative order. (An executive order from the White House will abolish Interior's old Petroleum Conservation Division, administering the Connally "Hot" Oil Law, and transfer its functions to the new unit.) So, the new division will have no new powers not now held by the federal government.

At policy-making levels, the new unit will coordinate the oil and gas activities of other departmental units such as Bureau of Mines, Geological Survey and General Land Office, but it is not contemplated that functions of these latter agencies will be taken over by the new division.

Besides unifying departmental petroleum policies, Interior's new unit will also keep the Secretary informed on "the adequacy and availability of the supplies of petroleum and its products to meet the current and future needs of the Nation" and to develop proposals looking to the centralization of federal oil and gas functions. This is in line with the President's letter of May 3 to Krug requesting that he keep the White House informed on "significant developments" in the petroleum field and "to consider and recommend such steps as may be necessary appropriately to safeguard our petroleum future."

The new division is expected to have subdivisions dealing with conservation and reserves, economics and supply, research, and technical matters. It is planned that Interior will thus become the government's fact-finder on oil and gas. This is an important function during the reconversion period. For example, during the fuel shortage—made critical by the coal strike—studies can be made of fuel oil supply, demand, yields, etc.

Another function of Interior's new petroleum unit will be to serve as the contact point of the federal government with state oil and gas regulatory bodies. This unit also can function as the hub of any interdepartmental oil board that is set up later.

● **PUBLIC LANDS.** Now that Secretary Krug has said Interior will go along with any policies adopted by the Senate Public Lands Committee on oil and gas leasing law changes, it is a good bet that the Committee will recommend (1) a flat 12½ per cent royalty on discoveries on public lands outside producing areas, (2) an increase of at least 100 per cent in the present acreage limitation (7680 acres) on public lands holdings of any one operator in a single state, and (3) a limit of 100,000 acres on holdings for geophysical prospecting.

Krug's attitude was in decided contrast with that of his predecessor, Harold L. Ickes, who was opposed to these changes and would have fought them right down to the time the President affixed his signature to the bill. Krug has adopted a policy of "Let Congress enact the laws, we will administer them to the best of our ability." It is winning him friends on Capitol Hill.

● **CONTINENTAL SHELF.** Interior's requested budget of $5,000,000 for a start on its 10 year program of oil and gas exploration of the Continental Shelf was deeply sliced by the Budget Bureau and again by the House Appropriations Committee. An effort will be made to have it restored as part of Interior's program for inventorying our natural resources.

Meanwhile, 15 cooperatives have been turned down by Interior in their applications for priority claims on 1500 sq. mi. of the Continental Shelf off the Texas-Louisiana coastline when and if this area is thrown open for oil and gas leasing as part of the public domain. Incidentally, the stretch of coastline covered in these co-op applications is the same as that surveyed with airborne magnetometer recently for Interior.

● **OIL PRICE CONTROL.** Although OPA probably will suspend ceilings on crude oil and all products (except possibly residual fuel oil) in the next few weeks to permit "moderate" price advances, the coal strike has made it unlikely that the industry will be freed entirely of price controls for months to come yet.

● **BIG INCH.** Several major oil companies continue to watch carefully all developments on disposal of the Big Inch and Little Big Inch pipe lines. Cooperatives have decided that they, alone, have not the volume to operate the lines as oil carriers. But the co-ops would be interested in participating if independent refiners or other shippers decide to go ahead with oil use plans. Meanwhile, the competition between gas interests for the lines grows keener. Realizing that War Assets Administration is committed to a preference for oil use, several gas groups have filed firm offers for oil-and-gas combinations (one line for gas, the other for oil). One of these groups, at least, has discussed oil use with several major oil companies.

● **ARMY BUYING.** War Department is seeking to take over from Treasury Procurement Division all the gasoline and fuel oil buying now done for the Army by TPD, coordinating these purchases with the Navy's under the Army-Navy Petroleum Board. Meanwhile, TPD is planning to cancel all government oil contracts that are tied to OPA ceilings, as soon as price controls are suspended. TPD will then buy in the open market until new bids can be advertised for, which should be good news to the small refiners.

● **STRIPPER WELLS.** An eleventh hour effort may be made to continue the wartime stripper well subsidy after price controls are suspended—but from the rate of progress so far, it will have to be greatly accelerated if it is to succeed. One proposal, still in the talk stage among one stripper well group, is that Interior Department and U. S. Tariff Commission cooperate on a study of a permanent price differential for marginal wells, using rate of production and depth as the yardstick for a particular well's differential.

● **POSTSCRIPTS.** Plans are moving along for a world-wide conservation conference, to include petroleum . . . Rubber Reserve Corp. (RFC) has agreed to loan up to 50% for purification units at plants of Premier Refining and Great Southern to make butylene concentrates for synthetic rubber manufacture . . . Senator O'Mahoney has asked for another $10,000 for his oil committee's work . . . Proposals for legislative oil divorcement, prohibiting any company from operating in more than one branch of the industry, are on the horizon but coming from a new quarter . . . Sale of Ohio Emergency Pipeline to the Ohio Standard is now before the Department of Justice for an OK.

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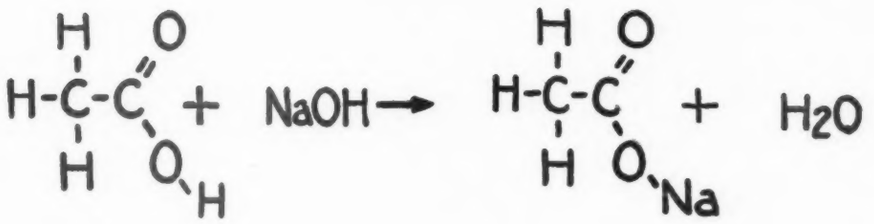

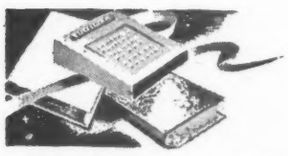

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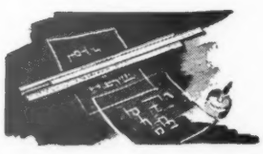

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NATIONAL PETROLEUM SITUATION

NEW OPERATIONS SLUMP. Continued uncertainty with respect to crude oil price control has had its effect in a slump in new drilling operations. Wells drilling at the close of April dropped to 3310, against 4150 a year ago. This represents a decline of 20 per cent under last year.

IMPROVED STOCK POSITION. Stocks of crude and all refined products are now about 16,000,000 bbl. greater than a year ago. Crude stocks are 1 per cent above a year ago, although refined stocks are 7 per cent greater. While fuel oil stocks are subnormal, they are now at about the same level as a year ago. Heavy imports and excessive production are factors in the replenishment of subnormal stock levels.

PRODUCTION ABOVE REQUIREMENTS. While some stock building is admittedly necessary, analysis shows that crude production in the first 4 months of 1946 exceeded actual requirements by about 68,000 bbl. daily. Production has been running about 2 per cent above normal requirements since January 1. The facts show that an increasingly greater share of the total demand for crude oil is being supplied by imports of foreign oil.

REFINING SHOWS STABILITY. Runs to stills in the first 4 months of this year have averaged about 4,616,000 bbl. daily, with actual requirements averaging 4,648,000 bbl. daily. Except for operating inequities between motor fuel and fuel oil, caused by unfavorable price controls, the refining situation has shown a fair degree of stability since January 1. Further efforts to improve the fuel oil supply picture were made in April by a reduction in motor fuel yields to 37 per cent, and a commensurate adjustment in production of fuel oils.

WILDCATS LAGGING. Wildcat drilling continues to lag, due to uncertainties over price control. The industry fell short of the quota set for 1945 by a substantial margin and results since January 1 of this year are below those recorded last year. If price controls are removed in the oil industry, as is now confidently expected this month, and if a needed upward adjustment is made in crude prices, it is likely that the search for new oil and gas fields will be more intensified.

GREATER GAS DEVELOPMENT. The development of natural gas reserves, particularly in the Hugoton and Panhandle Texas areas, continues unabated. Drilling data for the first 4 months of 1946 shows an increase of 8 per cent in gas well completions.

Comparative Statistics, April, 1946

*All figures are computed on a Bureau of Mines' Basis**

	April 1946	March 1946	April 1945	This year to date	Last year to date	Per cent change
Wells drilling	3,310	¶3,400	4,150	3,310	4,150	—20
Total wells drilled	2,211	2,359	2,169	8,851	8,107	+ 9
Development wells	1,904	1,977	1,849	7,603	6,828	+11
Oil	1,189	1,217	1,123	4,747	4,200	+13
Gas	196	217	219	813	751	+ 8
Dry	519	543	507	2,043	1,877	+ 9
Per cent dry	27.3	27.5	27.4	26.9	27.5	— 0.6
Wildcat wells	307	352	320	1,248	1,279	— 2
Oil	57	57	38	191	188	+ 2
Gas	10	7	8	35	42	—17
Dry	240	288	274	1,022	1,049	— 3
Per cent dry	78.2	81.8	85.6	81.9	82.0	— 0.1
Crude production	139,730	136,900	144,025	552,127	573,907	— 4
Daily average	4,658	4,416	4,801	4,601	4,777	
Crude demand	143,730	148,350	146,445	572,690	586,869	— 2
Daily average	4,791	4,785	4,882	4,772	4,891	
Crude stocks	231,400	228,400	229,644	231,400	229,644	+ 1
Days supply	48	48	47	48	47	
Natural gasoline production	9,650	8,950	9,258	37,493	37,137	+ 1
Daily average	322	289	309	312	309	
Motor fuel production	60,950	61,700	65,770	240,268	263,890	— 9
Daily average	2,032	1,990	2,192	2,002	2,199	
Gasoline yield, per cent	37.0	¶37.5	40.3	37.7	40.8	— 3.1
Motor fuel demand	65,450	60,350	71,719	234,964	257,724	— 9
Daily average	2,182	1,947	2,391	1,958	2,148	
Motor fuel stocks	97,150	101,650	84,436	97,150	84,436	+15
Days supply	45	52	35	45	35	
Fuel oil production	61,560	64,060	59,103	245,788	239,334	+ 3
Daily average	2,052	2,066	1,970	2,048	1,994	
Fuel oil demand	65,850	69,410	63,741	280,344	282,043	— 1
Daily average	2,195	2,239	2,125	2,336	2,350	
Fuel oil stocks	63,575	61,550	63,566	63,575	63,566	0
Days supply	29	27	30	29	30	
Refinery still runs	140,400	143,200	143,221	553,962	569,459	— 3
Daily average	4,680	4,619	4,774	4,616	4,745	
All refined stocks	235,875	235,008	220,443	235,875	220,443	+ 7
Days supply	44	46	40	44	40	

*Unless otherwise stated all figures represent thousands of barrels. ¶Revised.

Economic Position of U. S. Petroleum Industry

Four Months Ending April 30, 1946

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	9,000	8,851	98
Production (daily crude output)	4,533	4,601	102
Refining (daily still runs)	4,648	4,616	99
Stocks (crude and refined)	506,550	467,275	92
Price of crude (per bbl.)	$2.05	$1.33	65

Crude Prices by States for April, 1946§

U. S. average	$1.33	Louisiana	$1.32
Texas	1.31	Arkansas	1.13
California	1.17	New Mexico	1.10
Oklahoma	1.29	Mississippi	1.20
Kansas	1.30	Illinois	1.47
		Other states	1.99

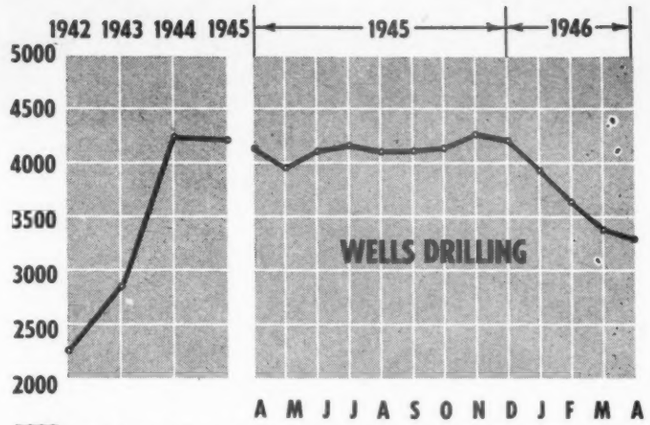
Basic crude prices

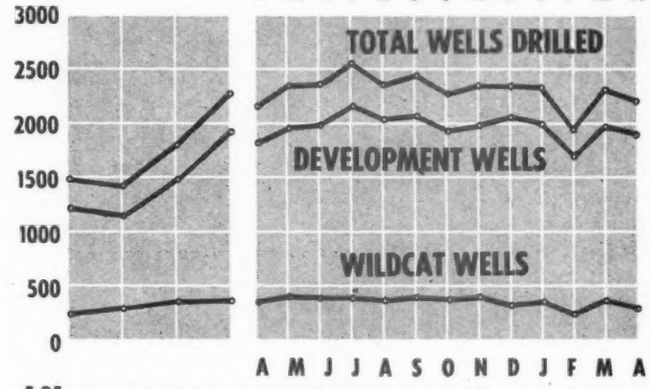
Oklahoma-Kansas (36 gr.)	$1.37
Texas Gulf Coast (36 gr.)	1.50
East Texas	1.35
West Texas (36 gr.)	1.14
Calif. Signal Hill (26 gr.)	1.21
Pennsylvania Bradford	3.10

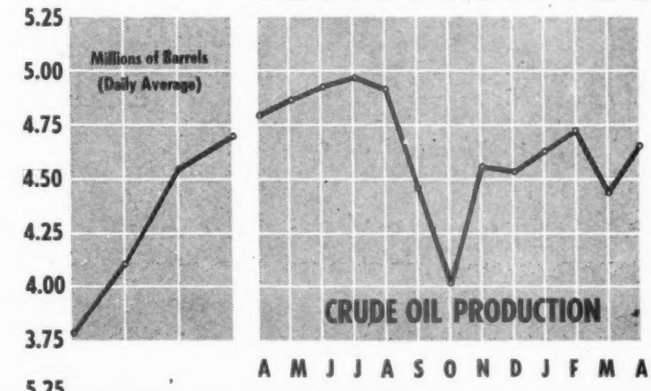
Drilling and Production Statistics by States

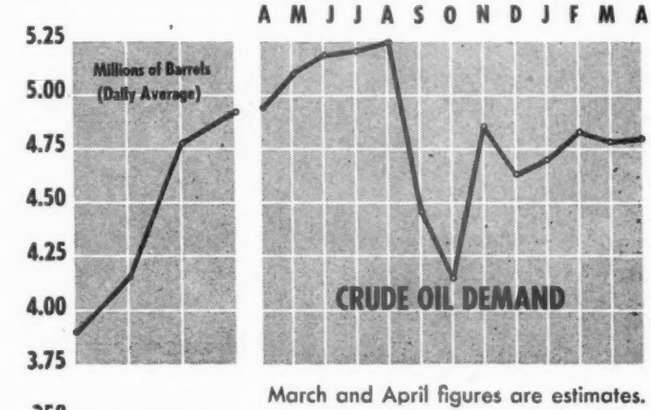
	April 1946	March 1946	April 1945	This year to date	Last year to date	Per cent change
Total wells drilled	2,211	2,329	2,169	8,851	8,107	+ 9
Texas	649	675	633	2,558	2,268	+13
California	157	162	196	599	776	—23
Oklahoma	168	200	191	763	734	+ 4
Kansas	138	159	128	625	486	+29
Louisiana	94	120	91	411	338	+22
Arkansas	17	10	13	57	40	+43
New Mexico	23	34	43	129	161	—20
Mississippi	18	24	32	79	107	—26
Illinois	202	173	101	688	485	+42
Other states	745	772	741	2,942	2,712	+ 8
Wildcats drilled	307	352	320	1,248	1,279	— 2
Texas	116	148	143	464	539	—14
California	16	26	18	80	73	+ 10
Oklahoma	28	38	23	148	122	+21
Kansas	24	18	27	89	108	—18
Louisiana	30	27	13	82	53	+55
Arkansas	0	2	1	8	13	—38
New Mexico	5	4	7	21	26	—19
Mississippi	2	12	14	24	47	—49
Illinois	37	26	23	128	93	+38
Other states	49	51	51	204	205	0
Daily crude production	4,658	4,416	4,801	4,601	4,777	— 4
Texas	2,029	1,854	2,164	2,003	2,162	— 7
California	873	852	917	853	903	— 6
Oklahoma	370	362	374	376	368	+ 2
Kansas	260	244	266	253	268	— 6
Louisiana	375	371	352	375	352	+ 7
Arkansas	77	77	80	77	80	— 4
New Mexico	96	94	105	97	105	— 8
Mississippi	56	54	51	55	50	+10
Illinois	204	211	205	208	207	0
Other states	318	297	287	304	282	+ 8

§Prices set by OPA. Prices do not include subsidies.
(p) Preliminary. ***Does not include input wells.

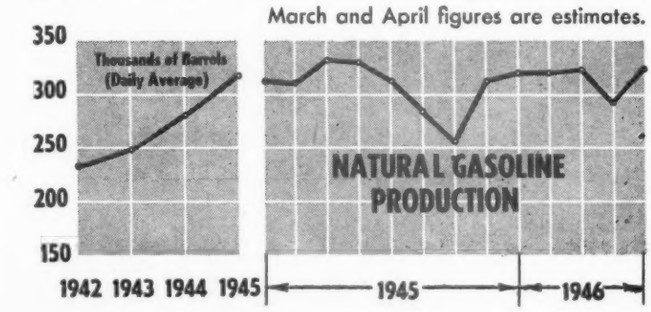


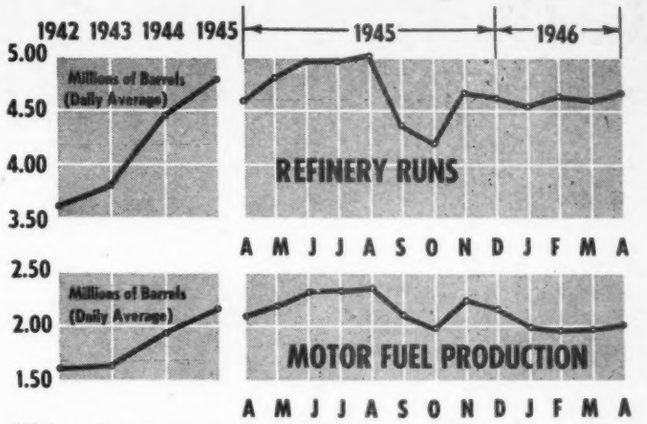


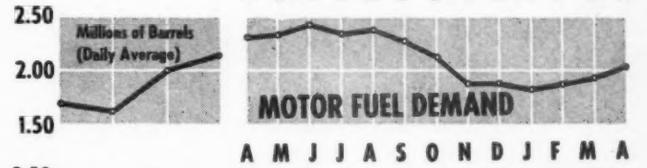


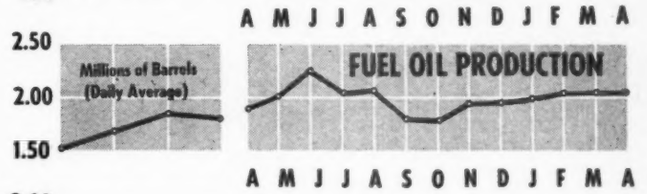


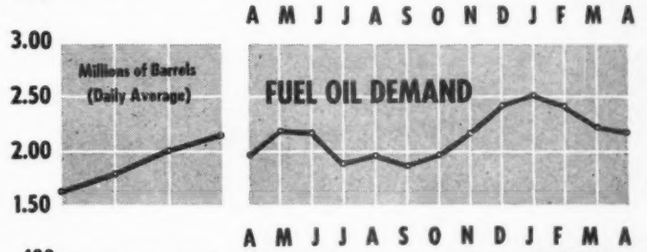
March and April figures are estimates.

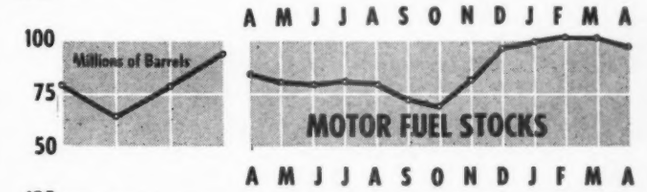


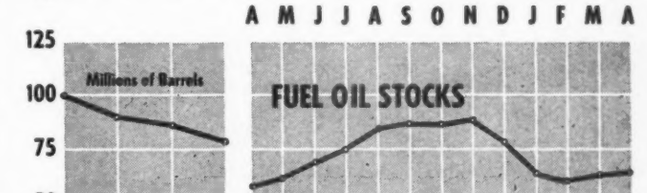


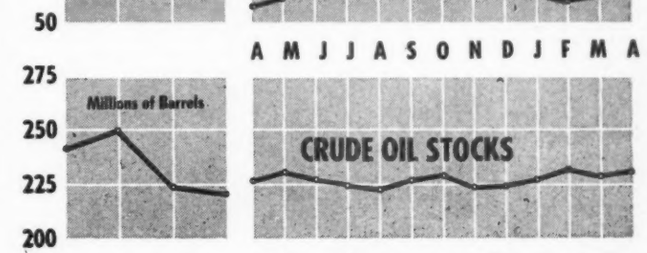




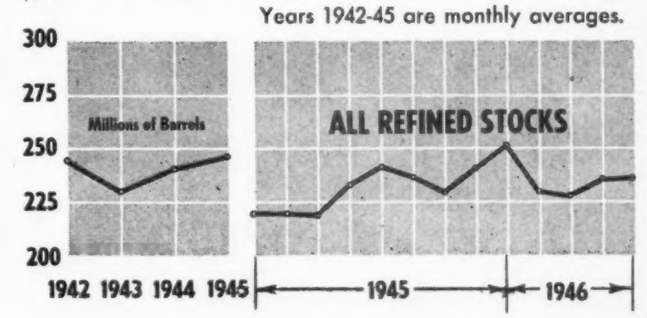








Years 1942-45 are monthly averages.



Highlights IN OILDOM

● **KRUG EXPLAINS AIMS OF NEW OIL AGENCY.** President Truman, in abolishing the Petroleum Administration for War, recommended that the government continue its liaison with the oil industry in peacetime. When he ordered the end of the wartime agency by May 8, he suggested that Secretary of Interior J. A. Krug establish a peacetime petroleum advisory council.

Krug, in explaining the oil and gas division being established in the Interior Department as the successor to PAW, has stated that it is not an attempt to obtain federal control of petroleum.

"The new agency will implement the President's direction to assure continued coordination of the Federal Government's many interests in oil and gas without in any way continuing wartime regulatory powers," Krug said.

A petroleum industry advisory committee similar to the war group also will be formed, Krug said, after the Justice Department has been consulted on the antitrust law features.

Krug said that members of the Petroleum Industry War Council will be asked to serve on the peacetime group, and independents will be given adequate representation.

Ralph K. Davies, Deputy Petroleum Administrator for War, will remain for a time to help establish the new oil and gas division and liquidate PAW.

In further discussing the Interior Department's plans, Krug said PAW did one of the great wartime jobs by finding ways to work with the petroleum industry. The new division will adopt the same tactics, he said. The division will work closely with the State Department on international petroleum matters, acquainting it, as well as the Army and Navy, with the domestic picture, Krug stated. The Interior Department oil conservation staff will be transferred to the new division.

● **TO RECHECK ITALY FOR OIL.** Standard Oil Company (New Jersey) has filed a preliminary petition with the Italian Government to expand its prewar prospecting in that country, and other companies are also reported to be interested. Although oil was first found in Italy a year after the Pennsylvania Drake Well discovered oil in the United States, commercial production always has been small. Now, however, with the widespread interest in increasing world petroleum reserves, it is thought that another look at Italy may pay dividends.

From 1860, year of first production, to 1945, total production in Italy was only about 3,500,000 bbl. This would constitute only 13 per cent of consumption in Italy in 1939 alone.

At present production is at the rate of about 100,000 bbl. a year, of which 90 per cent is in the Emilia region.

Small amounts of oil, as well as natural gas and some asphalt, are found elsewhere—in the Pescara Valley section of the Central Appennines; the Lucanina region in the Southern Appennines; Tuscany; Southern Italy, and Sicily.

Despite discouraging results in the past, however; geologists believe that extensive search with new methods and equipment may find substantial deposits.

Before war interrupted its explorations (which were continued under Italian Government supervision), Standard of New Jersey had spent nearly $5,000,000 under a 1926 concession, in geological surveys. The old concession limited it to development of tracts of not more than 2000 square hectares (4942 acres), too small, oilmen say, to warrant large expenditures. The company's new petition seeks the right to exploit larger tracts.

● **KANSAS COMMISSION ISSUES PRORATION RULE.** The most comprehensive statement of proration policy that has come from the Kansas Corporation Commission was issued recently as a memorandum opinion to its order establishing 20 acres as to the basic area attributable to oil wells in pools producing from formations less than 4000 ft. deep, and 40 acres as the maximum for wells in deeper pools. The statement was given to explain its reasoning in setting these limits.

The commission stressed that it does not have authority to prescribe well-spacing and that operators can drill as close a pattern as they please; but that legally it can determine how many acres a well can drain, and set standards for acreage credit in calculating production rates.

A cross-section of the oil industry in Kansas was provided in the opinion, which revealed that:

1. The prorated Kansas well averages 3500 ft. in producing depth, costs $27,500 to drill, complete and equip, and must earn $40,700 to amortize that investment in 15 years with 6 per cent interest.

2. West of Range 1, "where the bulk of our oil is produced," crude brings $1.17 a bbl. After paying one eighth royalty to the landowner, 30 cents "lifting cost" and 32 cents administrative expense per bbl., the operator has 40 cents for profit and to repay his investment.

3. At current prices, the well must produce 101,750 bbl. to pay off. If it makes 140,650 bbl., the profit will be $22,500.

4. If the OPA's tariff commission is right, and lifting cost averages only 13.5 cents a bbl., 72,212 bbl. recovered would net $40,700.

5. When the prospective price increase of 25 cents a bbl. becomes a reality, the $1.42 oil would amortize the average well investment with 62,215 bbl., at 30 cents lifting cost, or with 50,000 bbl. produced at 13.5 cents lifting cost.

6. On the average, Kansas pools recover 6200 bbl. per acre. To recover 62,615 bbl. ultimately, a well would have to drain 16.41 acres; to recover 50,000 bbl. "a fraction over 8 acres."

● **ACCIDENT SEVERITY RATE DECLINES, FREQUENCY RATE UP.** The severity rate of accidents in the petroleum industry declined in 1945, although the frequency rate (number of accidents per one million hours worked) showed an increase, the annual report of the Department of Accident Prevention of the American Petroleum Institute reveals.

Deaths and permanent total disabilities incurred among the 368,133 workers reported were 126, as compared with 1 6 in 1944 for 346,140 workers. Frequency of accidents rose from 13.57 per one million hours worked in 1944, to 14.43 in 1945. The greatest reduction in serious accidents was in the refining branch, where deaths and permanent total disabilities dropped from 64 in 1944 to 40 in 1945. These occurred among 125,365 workers.

Accident prevention work was begun by the Institute in 1931. The accident severity rate that year was 2.05 as compared with 1.35 in 1945.

● **ASSERTS CALIFORNIA TIDELANDS BELONG TO STATE.** Robert W. Kenny, attorney general of California, recently filed a statement with the United States Supreme Court summarizing the position of California as defendant in a federal government suit seeking to assert title to the tidelands, which contain valuable oil and mineral deposits.

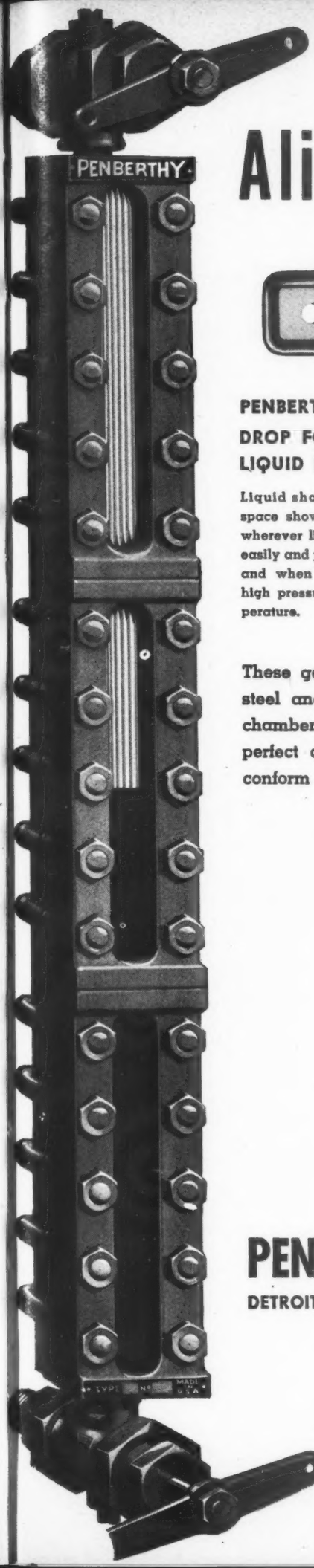
The shorter statement was requested by the court order after the Justice Department objected that Kenny's original two volume answer filed with the court was too long and contained a great deal of unrelated material.

Kenny told the court the federal government is not now and never has been, since California was admitted to the union September 9, 1850, the owner of the land extending between the low water mark and the three-mile limit off the coast of California.

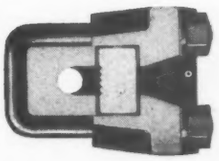
He said that "quite the contrary, the state of California owns those lands in fee simple absolute."

Kenny pointed out that since the Declaration of Independence on July 4, 1776, the 13 original states have owned their submerged lands under navigable waters.

California, he said, was admitted to the union "upon an equal footing with the original states in all respects whatever" and thus acquired similar ownership when it became a state.



Alike in Quality



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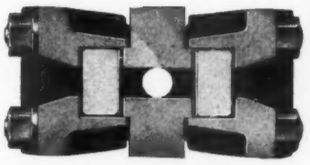

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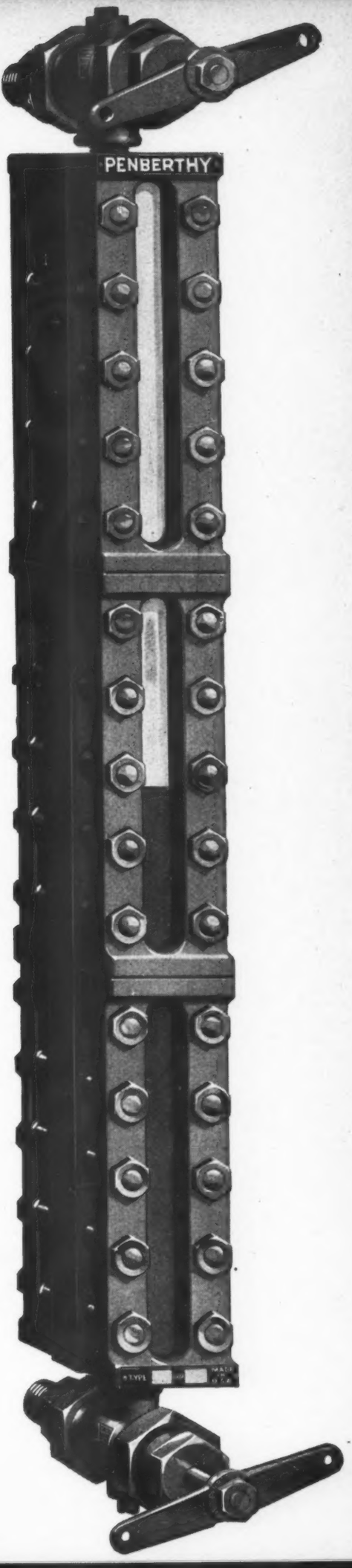

PENBERTHY INJECTOR CO.

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PENBERTHY PRODUCTS

MAJOR *Oil Field* ACTIVITIES

● **TEXAS.** Superior Oil Company No. 1 Coopwood has opened a new area in west-central Andrews County. The well assured production in flowing on two drillstem tests. The last test at 6848-7000 ft. total depth, brought an oil flow gauged at 260 bbl. in 5 hr.

Discovery well in Atascosa County is Humble's No. 1 Moursund, two miles south of Jourdanton. It was completed for 50 bbl. of oil per day on pump from 7382 ft.

Prospective pool opener for Starr County is George Echols No. 2 Garcia, south of the recently opened Parsons sector of the Rincon field. Production was estimated at 70 bbl. from sand at 3592-400 ft.

A new Travis Peak sand oil pool is believed assured for Marion County with Magnolia Petroleum Company No. 1 Orr. Latest gauge shows the well produced 101 bbl. of fluid in 12-hr., of which 70 per cent was 34.5-gravity crude oil and 30 per cent drilling mud, basic sediment, and water.

An Ellenburger discovery in Kent County and the most northeasterly well in West Texas is Humble's No. 1 Vick, C NW NE 45-5-H&GN. It recovered 73 bbl. of fluid on a 2-hr. gauge and flowed without swabbing after acidizing with 2000 gal. through perforations at 7775-810 ft.

Shell Oil Company No. 1 A. Nelson is the latest Ellenburger discovery in Andrews County. It is in the C NE SE, 8-A40-PSL. The well produced between 33 and 47 bbl. of 42.4-gravity of oil an hr. through a 10/64-in. tubing choke. Total depth is 10,453 ft.

An Archer County discovery is Grace and Grace's No. 1 Edwards, 2-2/3 miles southeast of the Scotland multi-zone field. Production is 5 bbl. of oil an hr. and is from conglomerate through perforations at 5490-5 ft. The producing formation was penetrated at 5214 ft.

● **KENTUCKY.** A new gas pool at the western limits of Owensboro has been opened by Watkins Drilling Company No. 1 J. E. Massie, NW NW NE, 25-p-29. Production is from a Waltersburg stray sand at 1158-68 ft. The well gauged 5,500,000 cu. ft. of gas with a rock pressure of 560 lb.

● **INDIANA.** A new oil pool has been opened in Posey County by the Peter Fox Brewing Company. The two wells that opened the pool are the Milton Andrey No. 1, which flowed at the rate of 380 bbl. in 24 hr. from a depth of 2,00 ft., and the Milton Andrey No. 2, which seemed to be somewhat better than the first well. The pool is just across the Wabash River from the Calvin oil pool in White County, Illinois.

● **OKLAHOMA.** Northern McClain County has a new oil field at Carter Oil Company No. 1 Thompson, C NE SE, 36-8n-4w. Production is from the Chimney Hill section of the Hunton lime where operators plugged back to test after finding salt water at total depth of 10,592 ft. in the Bromide. Flow was at the rate of 20 bbl. an hr.

A Dewey County prospect is Oklahoma Natural Gas Company's No. 1 Oakwood Unit, NWC, 6-17-4w. A drillstem test at 8003 ft. was unsatisfactory but 2700 ft. of oil and gas-cut mud was recovered.

There is promise of a new shallow oil pool in the southwest corner of Caddo County at Neil-Reed Oil Company's No. 1 Coyle, NE NE NE, 33-5n-12w, about 4 mi. southwest of Apache. Contracted to drill to 2500 ft., the Bromide formation was found at 100 ft. and operators reported saturation.

● **LOUISIANA.** The Little Temple area has a new oil field opener at Humble Oil and Refining Company's No. 1 Louisiana Delta Farms Company, LaFourche Parish, 19-17s-23e. Final gauge is 69 bbl. of fluid daily through a 3/16-in. choke with a gas-oil ratio of 582 cu. ft. to 1 bbl. Total depth of the hole is 12,007 ft.

Ohio Oil Company's No. 1-H Bond-Beene, 22-23n-8w, has opened a deeper sand zone in the Cotton Valley section of the old Haynesville field of Claiborne Parish. With total depth of 10,773 ft., casing was perforated at 9990-10,130 ft., and the well tested 476 bbl. of oil in 12 hr. through a 24/64-in. choke on tubing. Gas gauged 6,600,000 cu. ft. a day.

The world's deepest producing oil well is Shell Oil Company's No. 2 Smith-State Unit 1, at Week's Island, near New Iberia, Louisiana. It is producing 33-gravity crude oil from a depth of 13,778 ft. The former record holding well, only 400 ft. distant, was brought in by Shell a year ago and produces condensate from a depth of 13,520 ft.

● **MICHIGAN.** Pure Oil Company's No. 1 Freers, a wildcat about 8 miles from the Fork field in Mecosta County indicates the opening of a new depth of drilling in the state. It is coring below 5100 ft. in the thickest gas-condensate formation discovered in Michigan. Company officials said a daily gas flow of about 10,000,000 cu. ft. and 100 bbl. of condensate was indicated.

● **FLORIDA.** Humble Oil and Refining Company's well in Sunniland is promising to be a good producer. In an initial 11-hr. test the well flowed at the rate of 253 bbl. a day. Drilled to a total depth of 11,578 ft., it is located in the Everglades area in Collier County.

● **KANSAS.** Ninth discovery well of the year in Kansas is Alkay Oil Company's No. 1 Gray that opened a new Lansing-Kansas City lime production pool in Stafford County. Located in SW NE NE, 11-24s-13w, the wildcat was drilled to a total depth of 3882 ft. in the Viola and plugged back to 3774 ft. where it was completed.

Sedgwick County's new pool opener Beech Aircraft Corporation's No. 2 Hinkle, SW NE NE, 1-27-1e, was assigned a state potential of 828 bbl. of oil daily from the Burgess sand at 2992-95 ft.

A new shallow oil pool 5 mi. south of Walters in Cotton County is apparently being opened by Bridwell Oil Company No. 1 Houghton, SE NW NW, 23-3s-11w. An oil sand was penetrated at 1490 ft. and drilled to 1498 ft. On drillstem test there were 35 ft. of free oil and 95 ft. of oil-cut mud. The well was begun as an Ellenburger or 3600-ft. test.

Tom Palmer's No. 1 Lorbeer is being tested in Rooks County as an apparent pool opener. The location is SW SW SW, 28-7-19w, 3 mi. east and 2 mi. south of the new Alcona pool. The well logged good saturation in the Arbuckle at 3342-47 ft.

A new gas pool apparently is being opened at Continental Oil Company's No. 1 Skinner, a wildcat in the SE NE NE, 33-31-15w, 4 mi. west of gas production in the Skinner pool. At 4697½-720 ft., in the top of the Mississippi, the Skinner produced 2,500,000 cu. ft. of gas in an open flow test following acid treatment. Drilling was to 5167 ft. in the Arbuckle before operators plugged back to the Mississippi.

● **CANADA.** Royalite Oil Company's No. 1 De Winton, wildcat well, 1sd, 14-16-21-1w5, has aroused the interest of the Canadian oil industry. Located 15 miles south of Calgary and 13 miles east of the major Foothills oil field, Turner Valley, the test has discovered good porosity and oil saturation in cores from the Dalhousie sand at 8170-85 ft. and in the underlying Basal Fernie down to current depth of 8220 ft.

● **ILLINOIS.** The Keenville pool in Wayne County may have a new day of commercial-looking value at M. J. "Jack" Mitchell No. 2 Cornstubble, NE SE SE, 29-1s-5e. A drillstem test was made from 3090-110 ft. in the McClosky limestone that showed gas in 8 min. and a flow of clean oil in 58 min.

● **NEW MEXICO.** Lea County has either a new field or an extension to the Drinkard area at Humble Oil and Refining Company's No. 1-B Hardison, 32-21s-37e. Casing was perforated at 6420-80 ft. and 6500-60 ft. and the well acidized. On a test production was 624 bbl. of oil a day through tubing.

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FOR OIL INDUSTRY CHEMICAL SERVICE

MAJOR *Pipe Line* ACTIVITIES

● **SUPPLY GAS FOR LINE.** K. S. Adams, president of Phillips Petroleum Company, said that he expects an FPC certificate to be issued soon for construction of a gas pipe line from Dumas, Texas, to the West Coast. The project, on which a hearing was held April 12 at Los Angeles, is to be completed by the El Paso Natural Gas Company, and the Southern California Gas Company. Adams said his firm would supply much of the gas for the line.

● **CONSTRUCT LINES AND FACILITIES.** The Kansas-Nebraska Natural Gas Company, Phillipsburg, Kansas, has been granted permission by the FPC to construct, acquire, and operate gas transportation facilities in Kansas and Nebraska at an estimated cost of $1,575,000. The program includes the following: 1. Construction of a new 1000-hp. compressor station near Palco, Kansas. 2. Installation of a 1000-hp. compressor unit and auxiliary equipment at an existing compressor station near Scott City, Kansas. 3. Removal of a 500-hp. compressor station near Traer, Kansas, to the vicinity of Colby, Kansas. 4. Removal of three 450-hp. units from the Scott City compressor station and their installation at a new compressor station in the Hugoton gas field near Deerfield, Kansas. 5. Laying of approximately 56-mi. of 16-in. and 21-mi. of 12¾-in. pipe line extending from the company's existing pipe line near Phillipsburg, Kansas, to a junction with an existing pipe line near Hasting, in Adams County, Nebraska. 6. Replacement of approximately 56-mi. of 16-in. line extending from a junction with an existing line in Hamilton County, Nebraska, and terminating at a point in Thayer County, Nebraska, with pipe of smaller diameters.

● **PLANS APPROVED.** A study made by United States technicians for the construction of a pipe line from Camiri, Santa Cruz, to Tin Tin, Cochabamba, where an oil refinery will be erected, has been approved by the Bolivian government, it has been reported to the Department of Commerce. Cost of the project is estimated at $5,000,000, which will be borrowed from the Banco Central, the report said.

● **LONE STAR AUTHORIZES LINE.** The construction of a 7-mi. triple products line system has been authorized by Lone Star Producing Company. The line will extend from the natural gasoline and cycling plant being installed jointly with Rogers Lacy in the Carthage field, Panola County, Texas, to a 12-car rack at Carthage. Two 2-in. and a 3-in. will be used for handling natural gasoline, butane, and kerosine.

● **GIVEN PERMIT.** The Federal Power Commission has given the West Texas Gas Company, Lubbock, Texas, permission to operate 11 miles of 10¾-in. loop line in Hale County, Texas, as a permanent part of its system.

● **HEARING ON SHORT LINE APPLICATION.** The Federal Power Commission has set the date for hearing on an application of Natural Gas Pipe Line Company of America for authority to construct a short pipe line and necessary appurtenances to deliver natural gas to the plant of General Finance, Inc., Cloud County, Kansas. General Finance, Inc., has under construction a clay products plant in which the natural gas received from Natural Gas Pipe Line would be used in the process of drying and burning clay products. The new pipe line will be of 2-in. diam., and will originate at Natural Gas Pipe Line's present 26-in. main trunk pipe line in Cloud County and extend northerly for 240 ft. to a regulating and metering station to be constructed. The total cost of the project is estimated at about $6310.

● **NEW STANOLIND LINE.** Construction of a 20-in. crude oil line to be built between its Freeman and La Plata stations in Missouri, generally along the route of the present trunk lines, has been announced by Stanolind Pipe Line Company. They also plan to build a 14 and 19-in line between the Manhattan station and Little Calumet Junction, Illinois. Contracts for the construction have been awarded to the Oklahoma Contracting Company of Dallas, Texas; Sheehan Pipe Line Construction Company, Tulsa, Oklahoma, and Bechtel Brothers McCone Company, San Francisco, California. The construction work on these lines will begin promptly. The hauling and stringing on the jobs will be done by J. L. Cox and Son, of Raytown, Missouri, and Parkhill Truck Company, of Tulsa, Oklahoma. An intermediate pumping station will also be built on the 12-in. line between La Plata station, Missouri, and Wood River, Illinois.

● **CANADIAN COMPANIES ACQUIRE PIPE LINE SYSTEM.** All the outstanding stock of the Montreal Pipe Line Company, Ltd., which owns and operates a pipe line from the international boundary near North Troy, Vermont, to Montreal East has been acquired by four Canadian oil companies, British-American, Imperial, McColl-Frontenac, and Shell. In addition to this the companies, through a newly formed subsidiary, the Portland Pipe Line Corporation, have acquired all the assets of the Portland Pipe Line Company, which owns and operates a pipe line extending from Portland, Maine, to the international boundary where it connects with the line owned by the Montreal Pipe Line Company.

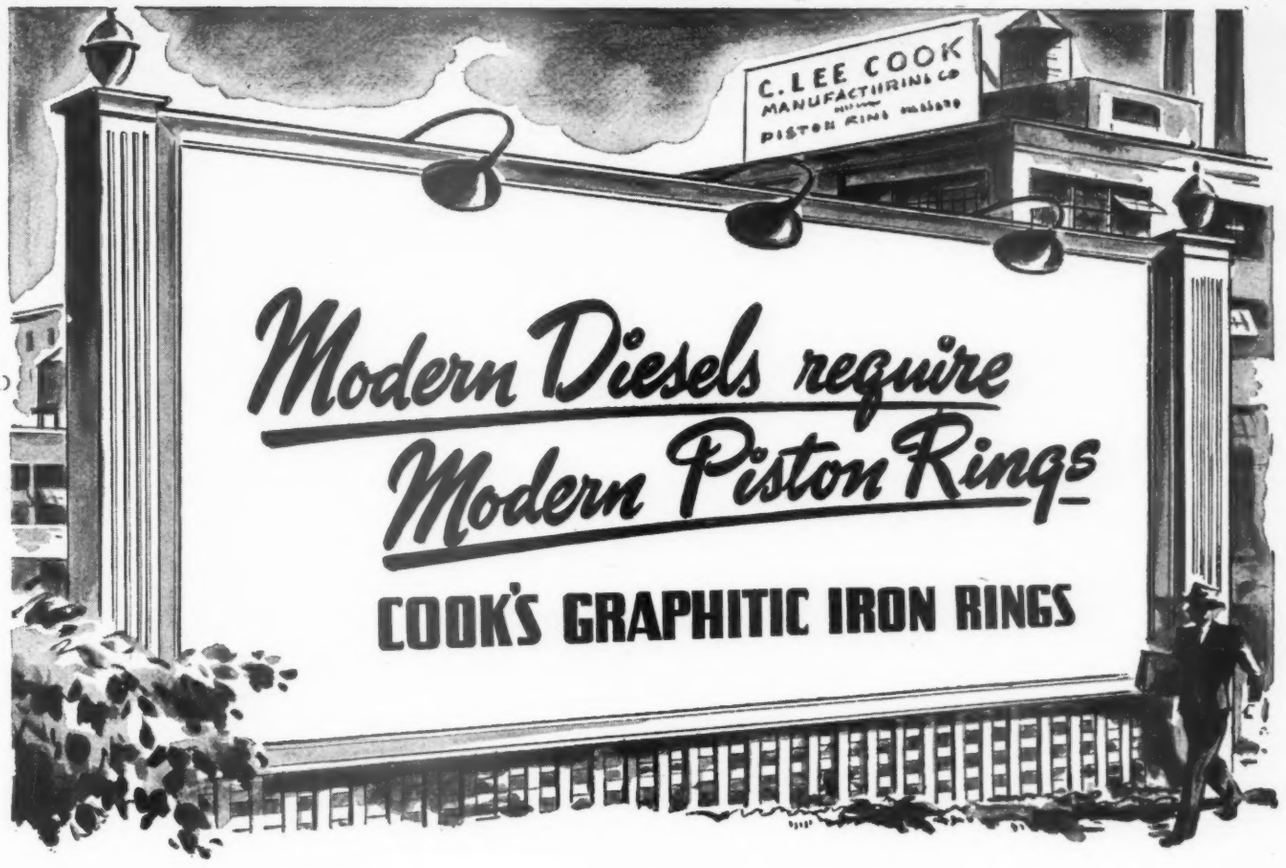
● **PROPOSE ENLARGEMENT OF SYSTEM.** Application has been filed with the FPC by the Mississippi River Fuel Corporation requesting authority to construct a number of additions to its natural gas transmission system that originates at Perryville, Louisiana, and continues through Arkansas and Missouri into Illinois. The company plans to construct a series of partial loops in each section of its main line, beginning at Perryville and extending to the vicinity of St. Louis, Missouri. The looping operation will require an aggregate of about 265 mi. of 22-in. pipe. They also plan the addition of 10,200 hp. to existing compressor stations. The new facilities would increase the natural gas sales capacity of the system by approximataely 50,000 M. cu. ft. a day to a total of about 183,000 M. cu. ft. a day. The company desires to begin construction by September and expects to complete the project by the first of the year.

● **ACQUIRE LINES.** Artesia Pipe Line Company has taken over the properties of the New Mexico Pipe Line Company amounting to about 107 miles of trunk and gathering lines. The lines serve the Artesia, Loco Hills, Grayburg-Jackson, and Square Lake pools.

● **PLAN FOR NEW GAS LINE.** The proposal of the newly organized Michigan-Wisconsin Pipe Line Company to construct a natural gas pipe line from Texas fields to serve Michigan and Wisconsin communities is being supported by officials of Wisconsin public utilities. The officials appeared at a hearing of the FPC on the application for the new natural gas line. The new company is a subsidiary of the Michigan Consolidated Gas Company, which now is supplied gas by the Panhandle Eastern Pipe Line Company. Panhandle Eastern is opposing the application. Milwaukee Gas Light Company officials also have appeared before the group in support of the new company.

● **GAS PIPE LINE.** A $25,000,000 pipe line from Kansas City to the Hugoton natural gas field in western Kansas will be constructed by Cities Service Gas Company in 1947. The 26-in. line, 405-mi. long, will be the largest project ever undertaken by the firm. The line will deliver 290,000,000 cu. ft. of gas a day to the Kansas City area, it was reported by the company.

● **GAS FOR CANADIAN SYSTEM.** The Federal Power Commission has authorized the Panhandle Eastern Pipe Line Company to construct $516,600 additional facilities, including a 16-in. pipe line in Michigan that would supply 5,500,000,000 cu. ft. of natural gas annually to Union Gas Company of Canada. The pipe line will connect with Panhandle Eastern's main 22-in. line at its Detroit regulator station in Allen Park, Michigan, and extend to River Rouge and thence to the west bank of the Detroit River where it will connect with two parallel 12¾-in. lines laid under the Detroit River to connect with Union's lines.



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MAJOR *Refining* ACTIVITIES

● **WEST TEXAS GASOLINE PLANT.** Stanolind Oil and Gas Company, The Texas Company, Magnolia Petroleum Corporation, and Honolulu Corporation have entered a participating agreement to construct a natural gasoline plant in the Slaughter field of the North Permian Basin. Stanolind will construct and operate the proposed plant, which will have a capacity of 100,000,000 cu. ft. of gas daily, and a portion of the residue will be used for field repressuring if feasible.

● **OIL REFINERY CLOSED.** E. W. Moutray, operator of a refinery north of Hawley, Texas, said that OPA and Civilian Production Administration regulations have made it impossible for him to operate further without loss and therefore he is closing his refinery. The plant has been processing 24,000 bbl. of crude oil a month.

● **SALVAGE JOB.** Shell Oil Company, Inc., is attempting a large and unusual petroleum salvage job at its reservoir at the Wilmington, California, refinery. The reservoir was formerly the storage place for surplus fuel oil with a capacity of 2,000,000 bbl. In the last few years the surplus fuel oil vanished and the empty reservoir was left with more than 250,000 bbl. of hydrocarbon residue on the bottom. As contractors refused to undertake the salvage job, Shell is doing it. Shell's salvage method works the solid mass with a bulldozer until it starts to flow, then pulls the heavy fluid with a drag to a sump where sticks, rocks, and other debris are screened out. Steam heats the fluid until it can be pumped. At a recent date nearly 200,000 bbl. of fuel had been salvaged, with about 60,000 bbl. still to be dredged out.

● **NEW UNIT.** Leonard Refineries, Inc., Alma, Michigan, is planning the installation of a new small-scale thermofor catalytic cracking plant that will incorporate the latest in catalytic unit design scaled to the requirements of the small refiner. The unit, the country's first small-scale thermofor catalytic cracking plant, will be constructed by The Catalytic Construction and Engineering Company, recently incorporated in Delaware.

● **REFINERY EXPANSION.** A coking plant and an Edeleanu SO_2 treating unit are being added to the General Petroleum Corporation refinery at Torrance, California, where wartime demand for military aviation gasoline brought erection of four great thermofor catalytic cracking units. The recycle coking unit is expected to be completed by June and is being built by the M. W. Kellogg Company. Two furnaces, four coking drums, and conventional fractionating facilities are included in the installation. It is planned to run about 17,000 bbl. of coking stock per stream day, with anticipated gasoline stock yield of from 18 to 20 per cent. Cost of the unit and supplemental facilities will be approximately $5,000,000. Engineering work has been completed on the Edeleanu unit and contract awarded to E. B. Badger and Sons Company. Installation is expected to be completed late this year or early in 1947. With facilities and services, the cost will be approximately $1,800,000.

● **80-OCTANE GASOLINE.** The Texas Company has announced the development of a new 80-octane unleaded aviation gasoline for all light plane engines, which provides a single fuel for both flying and maintenance operations. The statement said that this new gasoline overcomes the difficulties that accompany the use of leaded fuels in light plane engines. Combustion chamber deposits are reduced to a minimum, eliminating many costly valve troubles and overhaul problems.

● **ACQUIRE STORAGE PLANT.** Southeastern Oil of Jacksonville, Florida, has acquired 25,000,000 gal. of storage at Port Everglades, Florida. It will be used chiefly to serve the aviation gasoline requirements of the army and navy and will constitute one of the largest petroleum depots along the south Atlantic coast. More than $30,000 has been spent to clean and refit the terminal for storing petroleum products. The terminal was owned by Pacific Molasses Company and was built just before the war for nation-wide distribution of Cuban and Puerto Rican molasses, which was a critical war material for industrial uses and in the manufacture of explosives.

● **CHEMICAL CONSTRUCTION AWARDED FRENCH CONTRACT.** Chemical Construction Corporation has been awarded a contract by Office Nationale de l'Azote, of France, to design and supply the materials and equipment for a gas reforming plant to be constructed in Toulouse, France, on the Garonne River. The new plant, utilizing the methane steam process, will convert natural gas, by high temperature cracking, into hydrogen and nitrogen for use in the synthesis of ammonia. It will have a charging capacity of approximately 20,000,000 cu. ft. of natural gas daily.

Chemical Construction Corporation, a subsidiary of American Cyanamid and Chemical Corporation, is a leading American firm engaged in the design and construction of plants for the chemical industry. It has installed plants in most of the industrial countries of the world. Numerous patented processes are controlled by this company.

● **REPRESSURING PLANT IN OPERATION.** The West Pampa Repressuring Association has begun operating its repressuring plant in the West Pampa field in the Gray County sector of the Texas Panhandle. The necessary funds to erect and operate the plant were subscribed by major and independent companies. The project involves the return of gas to the oil zones in 16 sections of leases, and the initial runs apply to 50 key wells. Construction work was supervised by Walco Engeering and Construction Company of Tulsa, Oklahoma.

● **REFINERY FIRE.** The Salyer Refining Company refinery at Oklahoma City suffered $18,000 damage from a fire that was attributed to oil seepage that had run from a tank across the ground and into the firebox in the boiler room. Laboratory equipment and other machinery and much oil were a total loss. The fire spread over two acres of ground.

● **REFINERIES OFFERED FOR SALE.** The WAA is offering for sale three government refineries, built during the war for the production of aviation fuel and its component parts. The three refineries are: 1. Smith's Bluff, Texas, aviation alkylate refinery with a rated capacity of 1330 bbl. per day, a feed preparation unit and a sulphuric acid alkylation unit capable of 1200 bbl. of alkylate a day, and storage tanks for 55,000 bbl. 2. Duncan, Oklahoma, oil refinery, operated by the Associated Refiners, Inc., capable of producing as high as 5100 bbl. of 100-octane gasoline per day, storage tank facilities for 580,000 bbl. (atmospheric) and 27,000 bbl. (pressure). 3. Texas City, Texas, pentane isomerization unit, leased by Pan American Refining Corporation, rated capacity of 2540 bbl. of isopentane daily, storage tanks for 40,000 bbl. (atmospheric) and 60,000 bbl. (pressure).

● **REFINERY REOPENS.** Frank H. Dunn, president of Wilcox Oil Company, has announced that the company's refinery at Bristow, Oklahoma, shut down for the last 90 days, has resumed operations at capacity. The management took advantage of the situation to make minor repairs to the plant.

● **OPERATIONS AT ROTTERDAM REFINERY TO BEGIN.** The Houston office of the department of commerce has received a report to the effect that refinery operations are expected to begin shortly at Pernis, near Rotterdam. Repairs are being made to the cracking units, which were badly damaged during the war. It was also stated in the report that production of crude oil at Coevorden, in Drente, is about 1200 metric tons a month, a mere fraction of the estimated 150,000 tons of petroleum products required each month for the entire country.

THE Petroleum Engineer

MAY, 1946

LARGE RIG PNEUMATICALLY CONTROLLED

By K. MARSHALL FAGIN, *Field Editor*

A COMPARATIVELY new power-type rotary drilling rig* is shown in the accompanying illustrations as it was drilling ahead recently at a depth of 9200 ft. in a well near the town of Magnolia in Montgomery County, Texas. It is the first rig of this design that was put into drilling service, and the well, F. A. Callery's Thompson No. 1, is the seventh one that it has drilled. The rig is owned and operated by Newman Brothers Drilling Company.

EXCLUSIVE

As with all new rotary drilling rigs, this one has been operated for several months under the watchful eyes of field service engineers, tool pushers, drillers, and others interested in learning whether or not the rig would perform as well as designers intended. It can now be told that it is living up to expectations.

● **Instruments and controls centralized.** The rig is operated and controlled by small hand levers mounted in a protected instrument and control panel situated at the driller's position. Manipulation of these levers actuate compressed air valves that, in turn, operate all clutches including engine compounding, pump, and hydromatic brake clutches. Fig. 1 shows a close-up of the instrument panel as it was when the well was drilling at 9200 ft. Notice that the three engine levers (upper left) are down in the "In" position and that the intake pressure of the engines (vacuum gauges below the engine levers) is about 13 in. of vacuum. The next lever to the right shows that engine No. 1 and engine No. 2 are compounded. The next lever shows that engine No. 2 and engine No. 3 are not compounded. The next levers to the right indicate that the main slush pump is "In" and that the auxiliary slush pump is "Out".

*An "Oilwell" No. 96 Mechanical Rig manufactured by Oil Well Supply Company, Dallas, Texas.

The three engine throttles appear on the left center of the panel, No. 1 lever controlling both No. 1 and No. 2 engines, which are compounded, and the oil pressure gauges, transmission speed tachometer, and various air pressure gauges appear on the right side.

● **Clutches actuated by air valves.** The remaining hand levers on the lower shelf of the instrument panel are from left to right: Foot pedal throttle compounding lever; hoist clutch lever (in the "Out" position); transmission lever having neutral, high, low, intermediate and reverse speeds (in "second" speed); rotary table lever (in the "In" position); master clutch lever (in the engaged position); in the opposite position the neutral brake is applied and all power is disconnected from the hoist, thus this lever becomes an emergency lever; and the drum clutches lever (in neutral position).

In addition to manipulating these levers and watching the gauges on the instrument panel, the driller has a long handled drawworks brake lever, a sand reel brake lever, a foot pedal throttle, a rotary cathead pedal, and another foot pedal for operating the rotary clutch when the sand reel is in operation. Fig. 3 shows the driller feeding off a little line from the drawworks drum spool by raising slightly the drawworks brake lever.

● **Rig designed to drill to 16,000 ft.** The rig with its three 6-cylinder, 8½-in. by 8½-in., gas engines is designed for drilling to 12,000 ft. with 4½-in. drill pipe and to 16,000 ft. with 3½-in. drill pipe. The engines are rated at 375 hp. at 900 r.p.m. Butane is being used for fuel at the present location.

In addition to its other features, the rig has been designed to be moved easily by unitizing the machinery on steel skids. The drawworks with its transmission, for example, can be moved as a single unit, forming a compact load 21½ ft. long, 9½ ft. wide, and 8 1/3 ft. high, including the sand reel.

When preparing to move the drawworks, it is only necessary to disconnect the drive chains from compound to drawworks and from the drawworks to the rotary table. Covers can be placed over the openings in the guards to prevent dirt or water from reaching the working parts when the unit is being transported. An 8-ft. road clearance can be obtained when necessary by simply unbolting the transmission unit from the drawworks frame and disconnecting the flexible couplings to the high and low-speed jackshafts. It is not necessary to remove any chains.

● **Dismantling procedure simplified.** Each of the three engines is mounted on an individual skid-type sub-base, and the unitized compound transmission for the drawworks and pump drives is mounted on a skid-type sub-base. The procedure for dismantling this compound drive for moving is as follows:

1. Disconnect the drive chain from compound to drawworks.
2. Disconnect V-belt drives between compound and slush pumps.
3. Disconnect throttle controls, air and vacuum lines by removing bolts from two flanged couplings (all air lines between compound and drawworks are grouped compactly and designed to prevent connecting improperly).
4. Remove bolts and dowels that hold the compound drive assembly in place across the engine skids.
5. Move compound drive assembly away from engines sufficiently to clear the clutch drums that are attached to the engines.

The compound drive assembly is then ready to be loaded. The three engine assemblies and the two slush pumps can then be handled as individual units.

● **Drawworks has six forward speeds.** The drawworks is driven through a self contained, inside-mounted transmission having three forward speeds, through sprockets and roller chain drives, and one reverse speed through single helical gears. This gives the drawworks six forward speeds and two reverse speeds using the high and low drumshaft clutches.

The drawworks transmission clutches are operated by air cylinders controlled from the driller's position by small levers. An interlocking device prevents accidental engagement of two clutches simultaneously. The transmission output shaft is in line with the high and low drum jackshafts. Each jackshaft is mounted in a rigidly supported pedestal having wide-spaced bearings and each is removable as a unit. This results in no overhanging load on the transmission shaft.

The high-speed jackshaft is connected to the transmission through a spline-type flexible coupling, and the low-speed jackshaft is connected to the transmission through a spline-type air-operated clutch. An extension of the input shaft is provided with a band-type neutral brake that is operated by an air cylinder. This brake quickly stops all shafts, so that shifting time is reduced to a minimum.

● **Guards arranged for accessibility.** The drawworks guards are arranged to provide maximum accessibility for inspection and maintenance of all bearings, clutches, and brakes. Both high and low-speed drumshaft clutches are of the constricting† type and have renewable friction shoes. The low and high sprocket and the clutch element are self-contained, being mounted on a sleeve, and can be removed from the shaft as a unit. The friction elements of the clutch can be replaced easily inasmuch as they are on the outside of the drawworks frame. It is only necessary to unbolt the clutch carrier from the sleeve and disconnect the air and water connections.

The large diameter and extra length of the drum spool (28 in. by 48 in.) requires fewer wraps on the spool for any given length of line. This tends to reduce line wear. The special heat-treated alloy-steel brake flanges are series water cooled to obtain low operating temperatures and reduce wear and increase the life of the brake lining and flanges. Braking is accomplished by patented full-wrap brakes of the combination band and shoe type. These brakes are designed with a spring-centered equalizer at the dead ends, which are readily accessible for making brake adjustments.

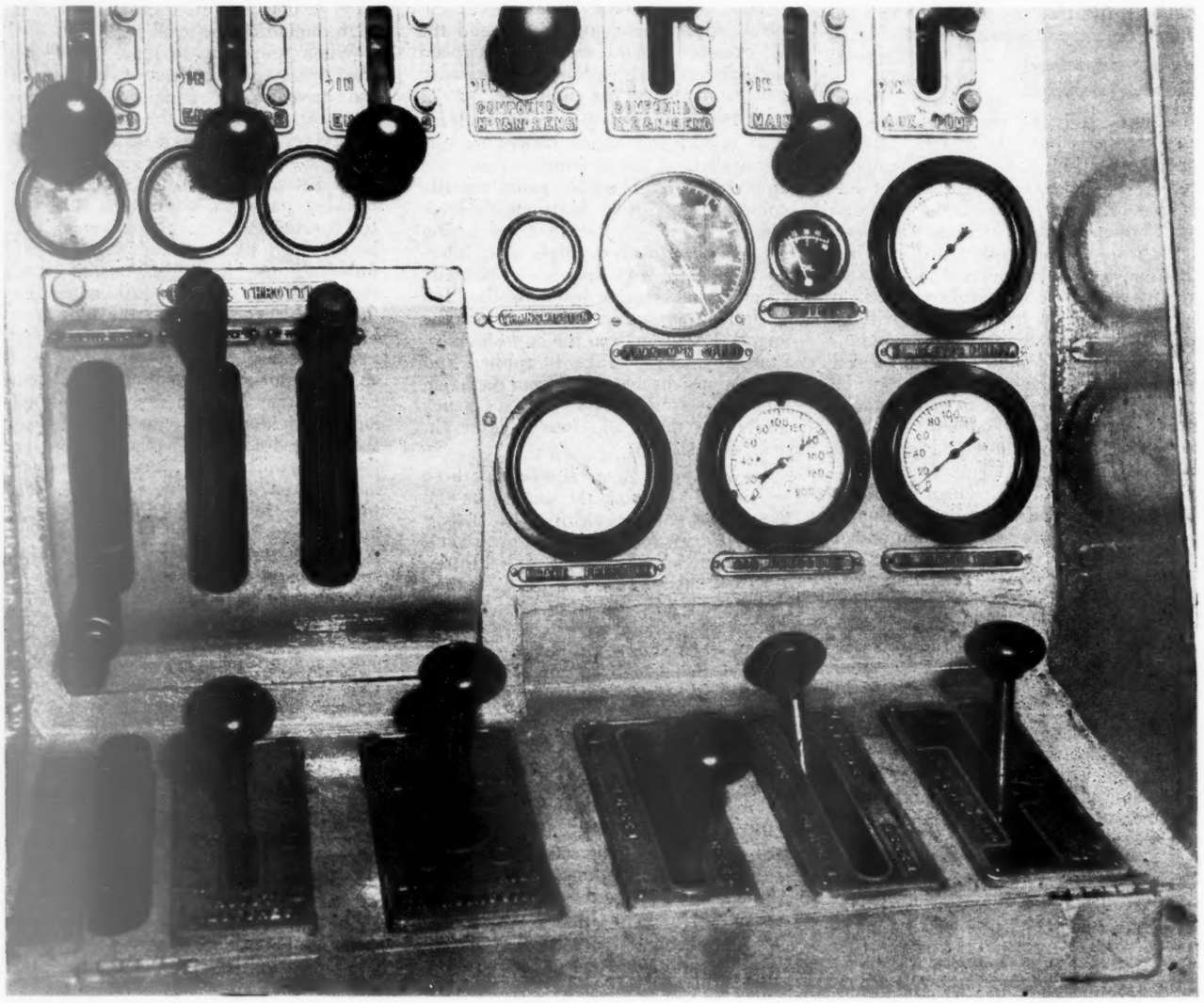
The brake hand lever at the driller's position is connected to the brake bands through a compound brake leverage system that produces high mechanical advantage, quick stops, and positive holding of the load. The brake lever is balanced and equipped with a locking device that enables the driller to hold it in any desired position. An auxiliary air booster on the brake mechanism can be used at the driller's option to reduce the manual effort required to handle the brake when operating at great depth. This booster may be cut out by merely closing the air inlet valve when the brake is used for feeding off.

The sand reel and assembly is mounted on the lineshaft. It has a capacity of 12,500 ft. of $\frac{5}{8}$-in. wire line and is equipped with a band-type brake through a compound brake leverage system with high mechanical advantage.

● **Shafts are mounted in roller bearings.** The main shafts of the drawworks

†Airflex made by Fawick.

FIG. 1. Instrument panel.



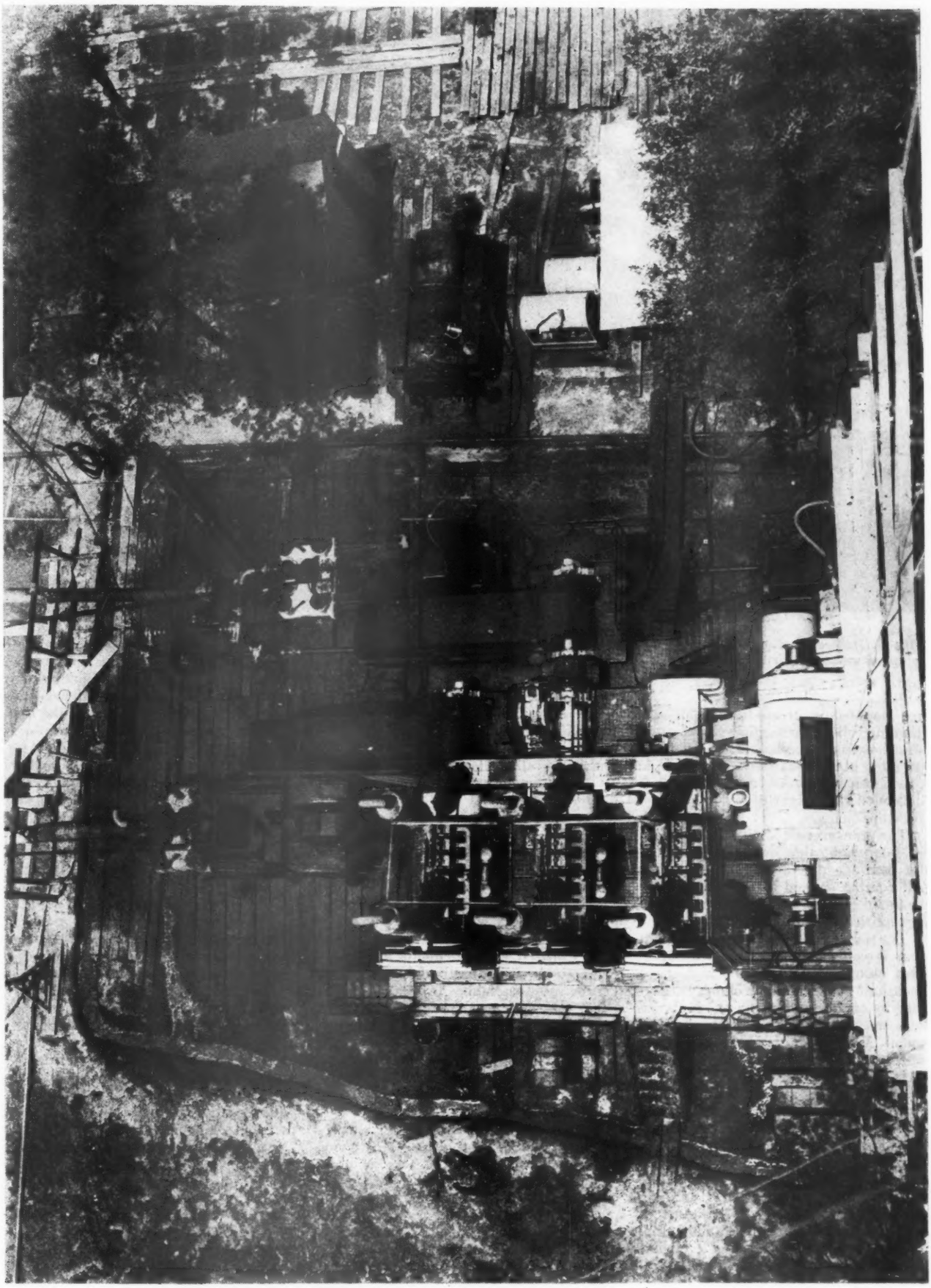


FIG. 2. General view of the layout at F. A. Callery No. 1 Thompson. This is the seventh well that has been drilled by the rotary drilling rig, which is owned by Newman Brothers Drilling Company, San Antonio, Texas.

FIG. 3. Driller feeding off line from drawworks drum spool.

are mounted in grease-lubricated, self-aligning roller bearings in weather-proof steel housings. One bearing is fixed and the other is allowed to float with this type of mounting, in order to eliminate shaft deflection that might occur due to temperature changes.

The transmission shafts are mounted in interchangeable double-tapered roller bearings that are shim adjustable. All floating splined clutch spockets are mounted in tapered roller bearings and are lubricated with grease.

The rotary is driven by a countershaft that is connected through an air-operated clutch situated on the high-speed jackshaft extension. The clutch is operated by compressed air by manipulation of a small lever on the driller's control panel. A foot pedal is also provided for operating this clutch when the sand reel is in operation.

● **Chain drives are oiled by pressure sprays.** All chains are lubricated by a pressure spray system to increase chain and sprocket life. The oil pump, placed near the sump, is driven by a chain from the jackshaft with pressure gauge mounted on instrument panel. The chain guards are designed to aid the return of the oil to the sump and to prevent it from reaching the brakes or friction clutches. The drawworks transmission has an independent spray lubrication system. Clutch and brake lever mechanisms are lubricated through grease fittings grouped at convenient points and accessible through doors in the drawworks guards.

Rig accessories include the following:

1. A double hydromatic brake with spline-type air-operated clutch that permits easy disengagement of the brake when traveling blocks are being raised.
2. Automatic cathead, air-operated by a foot pedal.
3. Hand-operated, spinning line cathead.
4. Low-speed jackshaft extension to permit application of an automatic hydraulic feed control.
5. Enclosed chain guard from drawworks to rotary with independent spray oiling system.

● **Unitized drive elements are straddle-mounted.** The unitized drive includes three shaft assemblies in which all driving elements are straddle-mounted in self-aligning roller bearings on rigid supports in weather-proof housings and equipped with grease seals and fittings. Each shaft is connected to one of the prime movers through air-operated clutch that serves as a high-speed flexible coupling.

Interchangeable multi-disk friction-type clutches are used on the No. 1 engine shaft assembly for driving the drawworks transmission and on the No. 3 engine shaft assembly with a V-belt pulley for driving the slush pump. The auxiliary slush pump drive operates from the No. 2 engine shaft assembly.

● **All clutches can be operated manually.** Multi-width chain drives are used on all sprockets, and spline-type clutches on the No. 1 and No. 3 engine shafts provide any compounding arrangement desired. All clutches used in this unitized compound drive are independently operated by air controls from the driller's control panel. In case of air failures, the coupling on each engine shaft and the clutches to the drawworks and the slush pumps can be manually operated.

The chains used in the compound transmission are spray lubricated and fully enclosed in oil-tight guards in sump and pressure gauge to prevent oil leakage or the entrance of foreign substances into the lubricating system.

Air for the control system is supplied by three compressors that operate independently of each other. One compressor is situated on the sub-base of each engine assembly and is driven by a special power take-off. In this way, air pressure is built up immediately after starting the first engine. Two of these air compressors supply enough air for all operations, leaving the third compressor as a standby. The compressed air is stored in excess of immediate requirements in a dual reservoir mounted on the compound drive assembly. It is equipped with safety valves and water traps.

In designing this rig one of the main goals was to construct a rig that could continue to operate while a particular drive, bearing, clutch, or shaft assembly was being cleaned, adjusted, repaired, or replaced. Likewise, considerable effort was made to use as many interchangeable parts as possible to facilitate repairs and replacement. ★★★

GALVANIC COUPLES AND CATHODIC PROTECTION

By **M. C. MILLER,** *Electrical Engineer,*
Ebasco Services Incorporated

MANY years' experience in the Southwest shows that, with but rare exceptions, corrosion leaks have been stopped on buried steel pipe lines by cathodic protection—where a pipe-to-soil potential of minus 0.80 to minus 0.85 volt has been maintained, as measured to a copper-sulphate electrode contacting soil over pipe line and using suitable instrument.

EXCLUSIVE

Although this criterion for complete stoppage of corrosion is used by most cathodic protection engineers in the Southwest, the reason for this pipe-to-soil potential is not readily apparent. Many engineers question whether it is necessary to maintain this pipe-to-soil potential at all points throughout the section of line being protected. There is much evidence that it is not necessary to do so—that corrosion is stopped even though the pipe-to-soil potentials may be minus 0.5 volt or even lower at numerous points along the protected line. On bare or poorly coated lines, the amount of power required to maintain minus 0.85 volt minimum at all points may be 3 or 4 times the minimum amount necessary to stop corrosion—increasing the initial installation costs and the annual cost of electric power.

A series of tests was conducted on buried pipes of different metals, arranged to permit correlation of galvanic currents, pipe-to-soil potentials over anodic and cathodic areas, and effects of increments of cathodic protection current on galvanic currents and pipe-to-soil potentials. These showed pipe-to-soil potentials at point where galvanic current (and resulting corrosion) was stopped; also meaning of pipe-to-soil potentials along the pipe line before cathodic protection is applied.

The tests show that a more reliable method should be developed for determining minimum amount of current required for protection of buried metal structures. This will be evident from a study of the accompanying charts, which were selected from the many tests made.

These tests show other important factors, effects that various locations of reference electrodes have on measured potentials; meaning of pipe-to-soil potential of a pipe line before applying cathodic protection; effects of relative size and potential of cathodic and anodic areas on division of cathodic protection current; effects of ground bed location; potential necessary to protect buried structures of other metals such as copper or galvanized steel; and many others. Primarily in this article, discussion will be limited to the relationship of galvanic couples to cathodic protection current and potentials, but some of the other effects are shown on the charts.

The buried pipes used for these tests were arranged so that the location of the anodic and cathodic areas would be known; also, their areas, open and closed circuit potentials, their resistances to remote earth and to each other, and the amount of galvanic current flow between them. With this arrangement, the division of cathodic protection current to the anodic and cathodic areas was determined accurately. About 45 sets of tests were made each involving about 20 sets of current and potential readings. Pipe-to-soil potentials to $CuSO_4$ reference electrode were measured for each current value—2 electrodes were buried about 1 in. from the surface of the pipe (1 over the anode and 1 over the cathode); 2 were placed on the surface of the ground directly over the pipe, referred to as 30 in. over, as the pipes were about 30 in. deep;

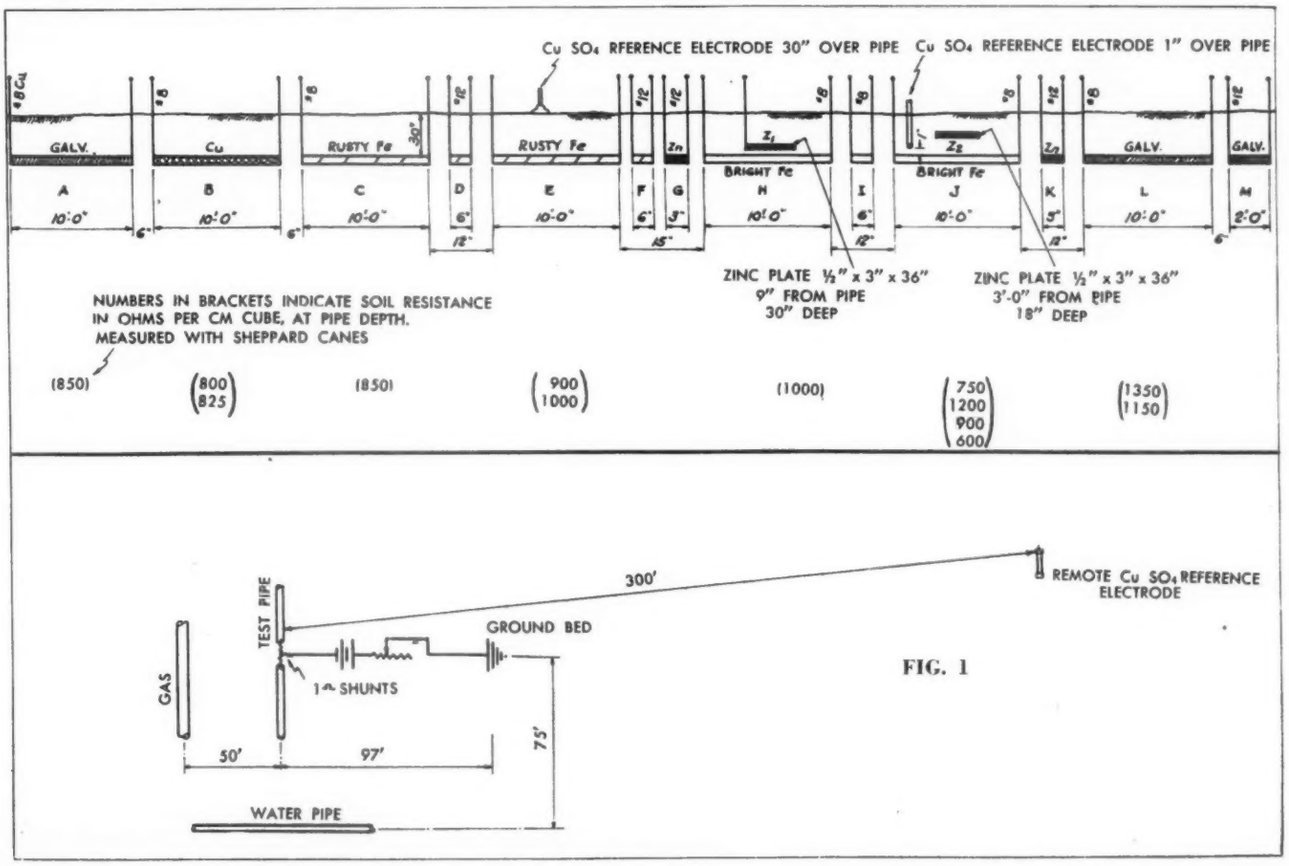


FIG. 1

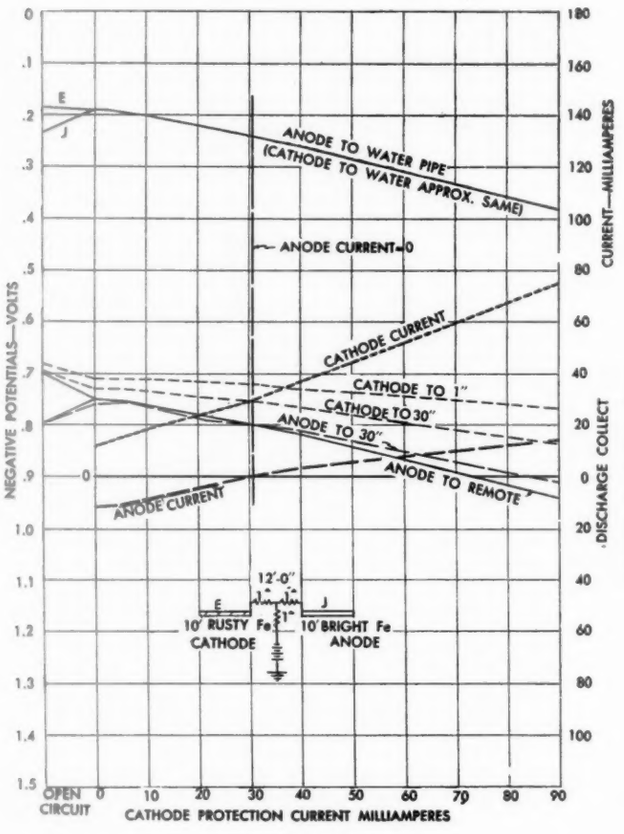


FIG. 2

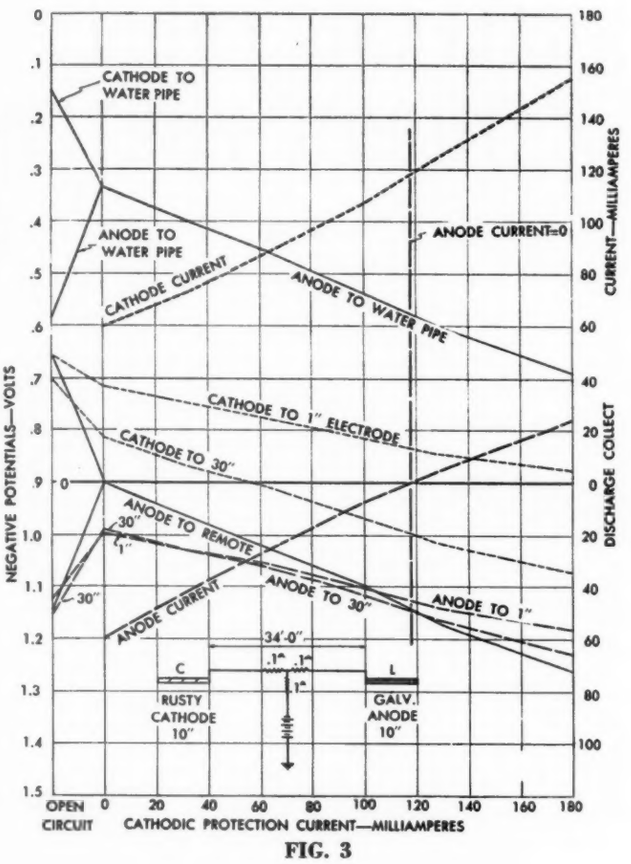


FIG. 3

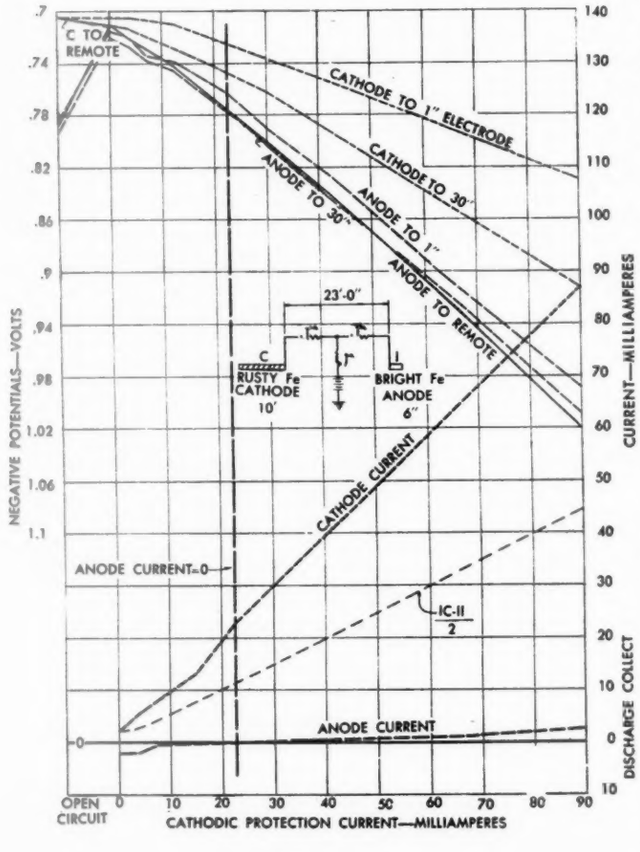


FIG. 4

and 1 remote electrode was placed about 300 ft. from the pipes. Potentials were measured also to a water pipe some distance away and to a galvanized iron fence of considerable extent. The soil was wet clay with a resistivity of about 1000 ohm per centimeter cube.

In charting the test data, two outstanding facts appeared in practically every set of tests regardless of controlling conditions, such as relative size of areas, potentials and resistance of cathode and anode. Briefly, they were:

1. When the net current flow from the anode was reduced to zero by the cathodic protection current, the potential of the structures to the 3 reference electrodes—the 1 in. and the 30 in. over the anode and the remote earth electrode—were practically the same and equal to the open circuit potential of the anode.

The potential of the structure to the electrodes that are 1 in. and 30 in. over the cathode was always less negative than to 1 in. and 30. in electrodes over the anode to the remote electrode.

2. The relative relationship of the potential of the structure to 5 reference electrodes is shown. The measurements indicated whether a pipe was an anode or a cathode and correlated with the measured flow of galvanic current.

Drawings to show these relationships accompany this article.

Fig. 1 shows the layout of test pipes, which were all bare, and relative location of fence, water piping, gas service pipe, remote 1-in. and 30-in. electrodes and remote ground bed for cathodic protection.

Fig. 2 shows potentials and currents for 2 steel pipes of equal size—"J" being brightened steel to be anodic to "E", which was rusty steel. Note that the open circuit pipe-to-soil potential of "J" was minus 0.8 volt to both the remote and the 30-in. electrode. The potential of the buried 1-in. electrode in this case was erratic and is not shown. The open circuit pipe-to-soil potential of "E" was minus 0.7, somewhat higher than would be expected for a rusty pipe. With "E" and "J" tied together (through 0.1 ohm shunts to permit measuring galvanic current and effects of increments of cathodic protection current) the pipe-to-soil potential of the structure was minus 0.75 to remote, minus 0.73 to electrode 30 in. over cathode "E" and minus 0.76 to the electrode 30 in. over anode "J". The galvanic current was 12 milliamperes

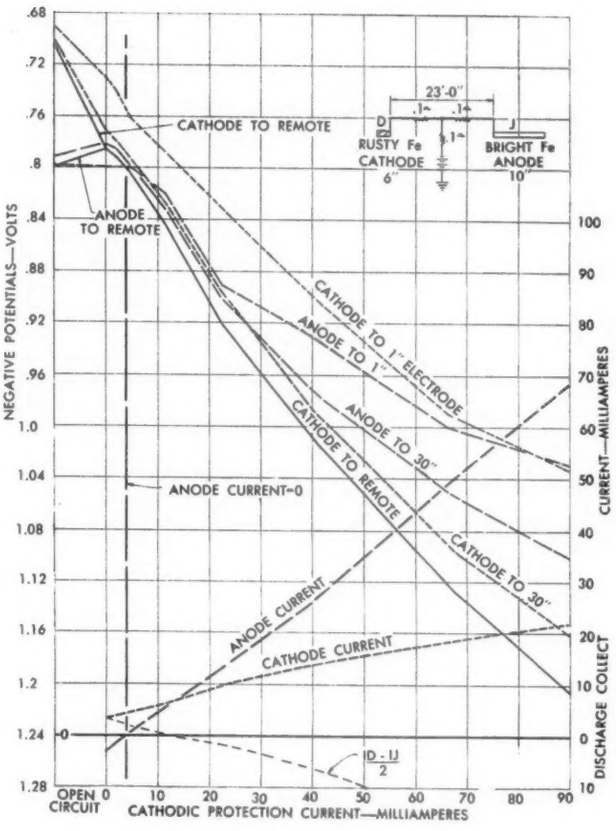


FIG. 5

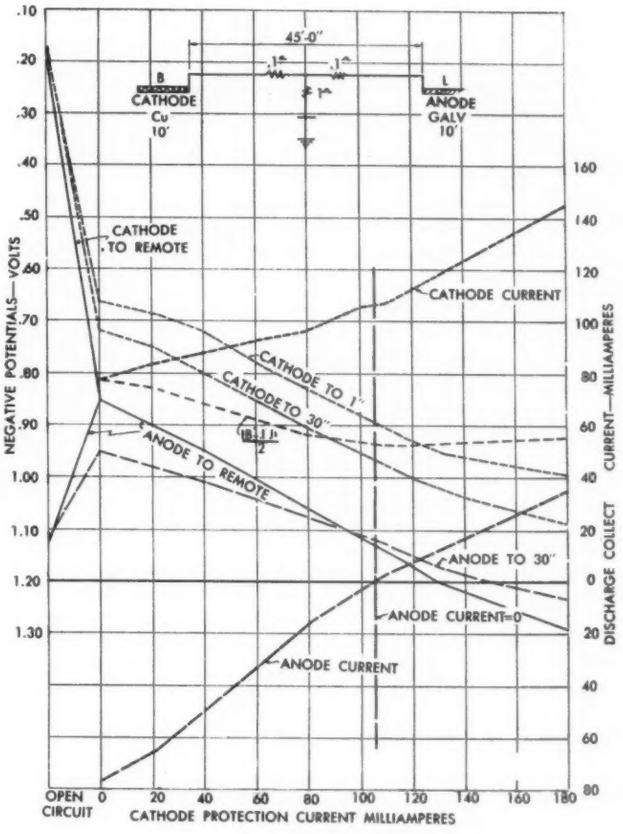


FIG. 6

(a few minutes after it had settled down to the effects of polarization).

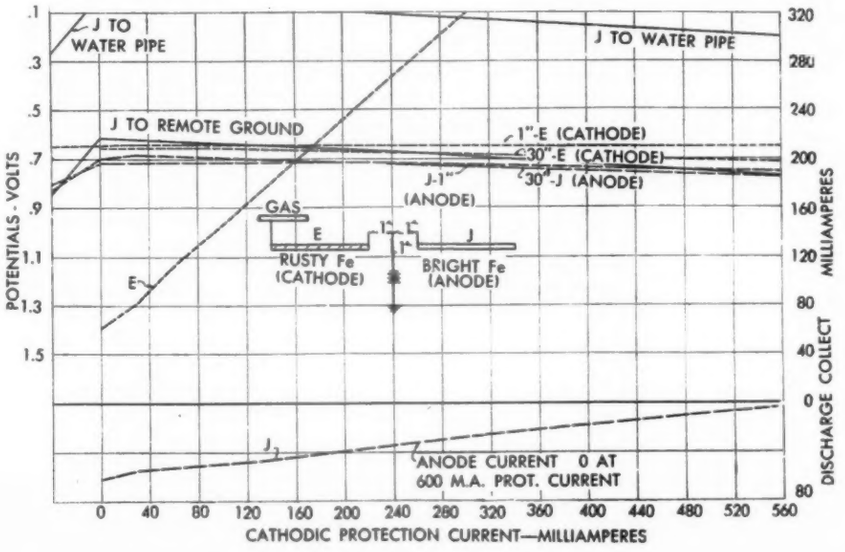
The pipe-to-soil potential of the structure became more negative to all reference electrodes (see chart) as cathodic protection current was applied and increased in small increments. At the point where the cathodic protection current balanced out the galvanic flow from the anode (shown on the chart by vertical dash line marked "Anode Current = 0), the potential of the structure to the remote earth electrode was again minus 0.8 volt, the same as the open circuit potential of the anode. Also, to the 30-in. electrode over the anode, it was minus 0.8 volt. Note that these two potential lines cross at anode zero current line. The potential of the structure to the reference electrodes 1 in. and 30 in. over the cathode was minus 0.72 and minus 0.76 even though the cathode was receiving the entire cathodic protection current — 31 milliamperes or approximately 5 milliamperes per sq. ft. of surface area of the cathode. To change the potential to the electrode over the cathode to minus 0.8 (as is now the general practice) required in this case 62 milliamperes, or double that required to stop corrosion. Note that 31 milliamperes of protection current was required to stop the flow of 12 milliamperes of galvanic current, a 2.5 to 1 ratio.

Fig. 3 shows similar potential and current data for a rusty steel pipe "C" as a cathode and a galvanized iron pipe "L" as an anode. With this combination the open circuit potentials of the anode and cathode were minus 1.15 and minus 0.65 to the remote electrode. Short-circuited, the structure potential was minus 0.9 volt to remote, minus 0.82 to electrode 30 in. over cathode "C," and minus 0.99 to electrode 30 in. over anode. The galvanic current was 60 milliamperes. Note that the pipe-to-soil potential as usually measured to the electrode over the pipe was minus 0.99 over the anode and minus 0.82 over the cathode. What would you do if you encountered these potentials in the field (with no cathodic protection applied)?

With this combination, 118 milliamperes of protection current were required to reduce anode current to zero, at which condition the structure-potential to remote electrode, 1-in. and 30-in. electrodes over anode were practically the same as open circuit potential of the anode "L"—approximately 1.13 volts. The potential of the structure to 1-in. and 30-in. electrodes over the cathode were minus 0.835 and 0.995 as shown.

Fig. 4 shows similar data for combination of a large cathode and small

FIG. 7



anode. Fig. 5 shows the reverse, a small cathode and large anode. In the first, a protection current of 22 milliamperes was required to stop a galvanic current of 2 milliamperes, a 11 to 1 ratio. In the second, a protection current of 4 milliamperes was required to stop a galvanic current of 3 milliamperes.

Fig. 6 shows data for a combination of copper pipe "B" as cathode and galvanized pipe "L" as anode. The galvanic current was 77 milliamperes with cathodic protection current of 106 milliamperes required to reduce anode current to zero.

Fig. 7 shows data for an extreme condition but perhaps is more representative of conditions on pipe lines. In this test, pipe "E" was connected to a gas service pipe, which was quite extensive and low in resistance to earth. The galvanic current was 62 milliamperes and 600 milliamperes were required to reduce anode "J" current to zero, a 10 to 1 ratio.

As shown by these charts, as well as other charts not included with this article, when the anode current was reduced to zero, the potential of the structure to a remote electrode was practically the same as the potential to the 1-in. and 30-in. electrodes over the anode and also approximately equal to the open circuit potential of the anode.

These tests indicate that to stop galvanic currents and so stop corrosion, it is necessary to change the measured potentials of the structure to remote earth or of the electrode near the anodes, so that they are equal to, or greater (more negative) than, the open circuit potentials of the anodes. Therefore, if the maximum open circuit voltage of the anodes likely to be encountered along a specific pipe line in a particular soil could be determined, it could be used as a criterion for protection and probably would be more accurate than using minus 0.8 or minus 0.86 volt for all conditions.

Other factors, such as the location of the ground bed, the separation of the anode and cathode, etc., will affect the accuracy of this criterion. For most of the tests referred to in this article, however, it is believed that adequate protection would have been attained by this method.

It should be emphasized that in all cases covered by the accompanying charts, the cathodic protection ground bed was relatively remote from the structure protected. Similar potential relationships may not be found where the ground bed is close to the pipe line, and in the case of zinc plates a few feet away from the line.

To what extent these data can be put to practical use in the field remains to be determined; however, they point to a number of factors:

1. The desirability of measuring pipe-to-soil potentials before cathodic protection is applied to determine to some extent the location of anodic and cathodic areas.

2. The fact that minus 0.8 volt to $CuSO_4$ electrode over anodic areas may be just about right for steel pipes, but considerably less than minus 0.8 volt may be sufficient over cathodic areas.

3. Whether minus 0.5 volt, minus 0.8 volt, minus 1.1 volts, or some other potential is required (over the anode or to remote electrode) depends on:

a. The metal in the structure,

b. The corrosivity of the soil, and

c. The location of the ground bed in relation to anodic and cathodic areas.

That these tests do not entirely duplicate actual conditions on a pipe line is fully appreciated. On a pipe line it is impossible or impractical to locate accurately anodic spots because on a length of pipe there may be half a dozen or so small anodic areas and the rest of the area (perhaps 98 per cent), is cathodic. Further, as there are numerous anodes and cathodes along the surface and each may have a slightly different dynamic potential, a complete analysis of these would be impracticable.

Apparently, many engineers have been confused on the meaning and significance of the potentials measured in the field. The pipe tests have been extremely enlightening. Study of the data has given a much better comprehension of the basic fundamentals of corrosion and cathodic protection. There is a real need for numerous similar tests to expand the industry's knowledge of the art. ★ ★ ★

P 615.63

MARKERS AID AERIAL PIPE LINE INSPECTION

With the advent of aerial pipe line "walking" new systems of marking the line for identification and ready reference to faulty sections have replaced the usual method of small metal numerals on telephone and telegraph poles.

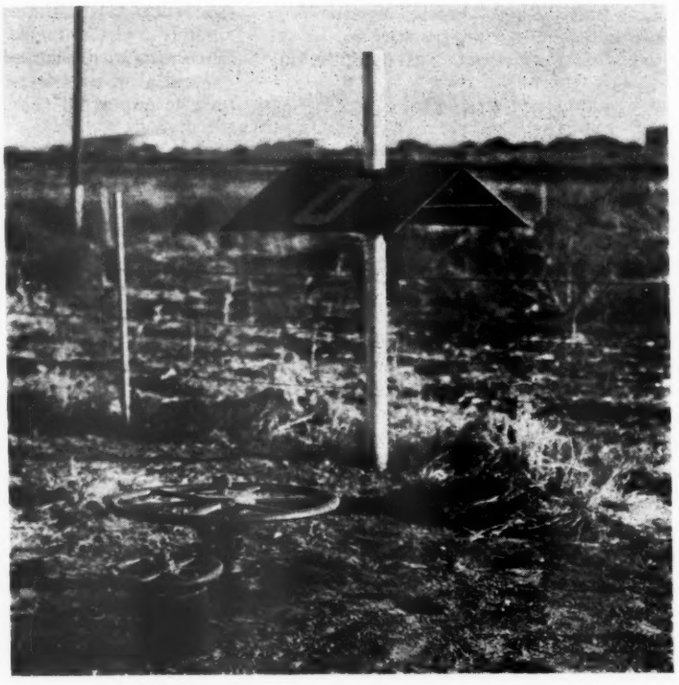
The marker used by one pipe line company illustrated here is visible from the air on clear days at 1000 ft., though the usual inspection is done at 500 ft. altitude by special permission. The 4-in. pipe post projects above the ground and has a "pup tent" of two pieces of tank steel 2 ft. by 4 ft. braced and welded in place.

Color contrast is assured for ready identification by painting the post and 18-in. numeral on each side of the pup tent aluminum and the background of the pup tent Air Corps Orange.

Markers are placed every 10 miles with numerals giving the correct mileage and a single post, without pup tent, is placed at every mile.

Pilot of the inspecting plane can identify to the nearest mile any trouble spotted on the line from the air by counting the posts passed enroute.

In brushy country the marker is placed high enough to clear the surrounding vegetation while in bare, western cattle country a different problem causes the markers to be placed on the ground. If mounted on posts, cattle find rubbing against the pipe support so invigorating that they all too frequently knock the marker to the ground while pursuing their simple pleasure. ★ ★ ★



FUTURE OUTLOOK for GAS TRANSMISSION LINES

By **M. L. MAYFIELD,** Petroleum and Natural Gas Consultant
Houston, Texas

● **Introduction.** Natural gas is one of the great sources of energy in the United States, contributing 12 per cent of the total power whereas coal supplies 51 per cent, petroleum 28 per cent, and electric and water power the remainder. It has become more and more evident in the past few years that whatever affects gas utilization and gas transmission business likewise will ultimately affect the oil business. A substantial portion, probably 85 per cent, of the nation's gas reserves are located in fields producing oil, some in separate zones and, in some cases, in the oil-producing zone itself. Therefore, any future transmission line expansion directly affects the economy and business structure of both the transmission and oil business.

EXCLUSIVE

At the present, total investment in gas transmission lines and auxiliary facilities is estimated at about $3,500,000,000, a marked increase since 1925 at which time this industry had an investment of $1,000,000,000. Approximately 40,000,000 customers in 34 states use natural gas, and gas consumption has shown a continued and successive upward increase until current consumption totals approximately 4¼ trillion cu. ft. annually.

After the late 20's and early 30's, a period of promotion and phenomenal growth, the gas transmission business has become stable, primarily through applied conservation technology by the petroleum industry as well as the cooperative efforts and better understanding on the part of all branches of the petroleum industry and the regulatory bodies. Each has grown to realize the value of gas reserves that occur in connection with the production of oil. This important contribution to the expansion in transmission and utilization of gas promises to broaden in scope as mutual understanding and joint efforts achieve greater conservation of casinghead gas. In the early days of the natural gas business, history shows that large reserves of dry and casinghead gas in some parts of the country were wasted and several transmission systems became failures. It took years before confidence was restored, with public assurances that gas reserves would be conserved and the high investment for long transmission lines could be placed on a sound financial basis.

Any forecast on the future of gas transmission lines suggests a brief review of historical information showing the expansion of such lines in the recent war period, the proposed or announced expansion of additional lines, and the consequence or ultimate effects such expansion might have on the oil business as a whole with particular reference to the economy of the State of Texas. At the present, Texas has approximately 60 per cent of the total gas reserves of the United States with about 90 per cent of the major transmission lines originating here. A majority of the new lines, either in the planning or talking stage, will seek their major sources of gas reserves from Texas fields and this fact has created considerable discussion both on the part of the public and the petroleum industry regarding what effect such pronounced expansion might have on Texas economy.

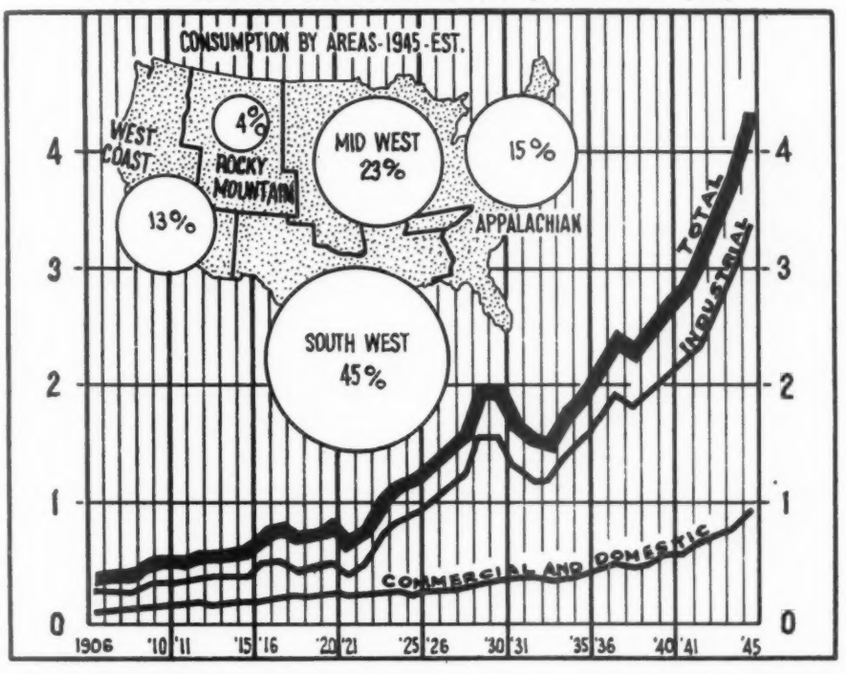
Many new natural gas lines will be required to supply the steadily increasing demand for this high quality fuel.

The physical characteristics of gas are such that it cannot be stored economically above ground in a volume sufficient to meet the impact of demands and the underground storage available in selected depleted reservoirs is so small compared to the volumes of gas used throughout the country that it is only of local benefit, so the pipe line companies, in figuring their demands, must require producers to maintain sufficient delivery capacity to meet, from the well to the consumer, the instantaneous impact of peak demands brought on by increased industrial loads and abrupt and severe changes in temperature.

● **Production and consumption.** Natural gas consumption has shown a sustained increase with very rapid expansion in the industrial field, particularly during the recent war period. Fig. 1.* clearly shows the trend of this upward consumption indicating that the domestic and commercial loads require 22 per

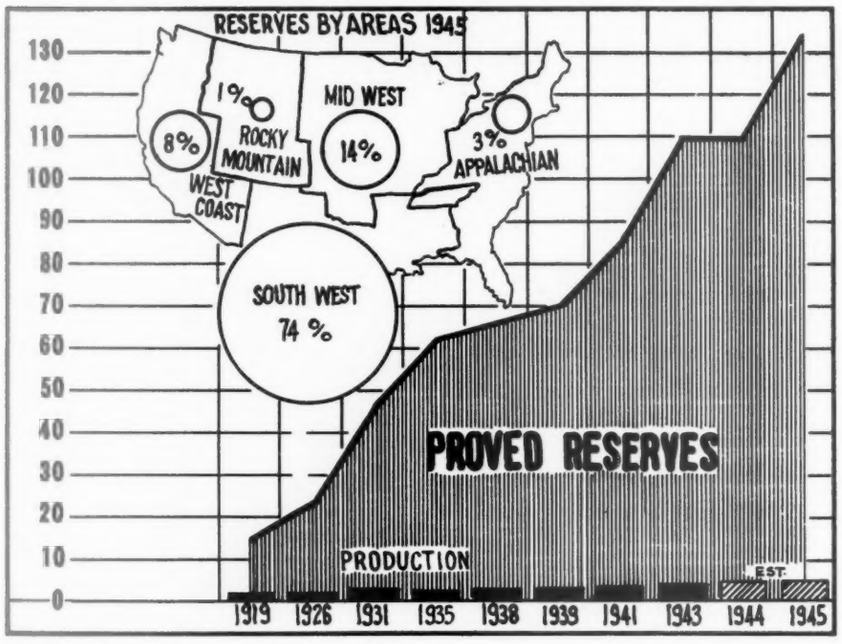
*"Petroleum in War and Peace," by James E. Pew, director of PAW Natural Gas and Natural Gasoline Division, before the O'Mahoney Senate Committee.

FIG. 1. NATURAL GAS CONSUMPTION *(Trillion cubic feet)*



Ohio and Kentucky are included with East Coast states in "Appalachian Region."

FIG. 2. NATURAL GAS RESERVE vs. PRODUCTION *(Trillion cubic feet).*



Ohio and Kentucky are included with East Coast states in "Appalachian Region."

cent with industrial requirements representing 78 per cent of the overall natural gas consumed. Total current consumption is approximately 4.3 trillion cu. ft. annually, representing a 55 per cent increase in the last 4-year period. Also shown on a percentage basis are relative quantities of natural gas consumed in the 5 geographic areas of the United States. Districtwise, the Southwest consumes 45 per cent, Midwest 23 per cent, Appalachian 15 per cent, Pacific Coast 13 per cent, and Rocky Mountain district 4 per cent. It is interesting to note that natural gas consumption did not reach a trillion cubic feet for approximately 20 years after its start in 1906, but in the last 15-year period, the total consumption has more than doubled. Obviously, such expansion, if allowed to follow its normal course without being overburdened with restrictive government legislation or control, suggests a very bright and encouraging market. According to the American Gas Association, the natural gas industry proposes to spend about $160,000,000 for plant expansion this year.

● **Natural gas reserves.** Evaluating the possibilities for such expansion suggests a review of the location of the major gas reserves and the trend of discovery as compared with the consumption and production of natural gas. On Fig. 2*, entitled "Natural Gas Reserves versus Production," is shown the estimated reserves of natural gas from 1919 up to July 1, 1945. On January 1, 1945, it was estimated the total gas reserves, including dry gas, associated gas, and solution gas, were approximately 135 trillion cu. ft., which was a substantial expansion of reserves during the war period despite the new high levels of consumption. With the introduction of cycling in 1937-1938, the growth of natural gasoline and pressure maintenance operations, total gas reserves became more significant in the average oil company's operations. Consequently, part of the indicated increase in the last few years may be attributed to the more accurate accountability of natural gas reserves.

Reserves by areas in 1945, based on the estimates compiled by PAW-Industry committees is considered to be comprehensive and reliable and shows the known recoverable reserves under present economic conditions; it does not necessarily represent the total quantity of gas that may be recovered if the fields are produced to lower exhaustion pressure than was assumed in the study. Reserves by areas in 1945 show that the Southwestern states, including Alabama, Arkansas, Louisiana, Mississippi, New Mexico, and Texas, contain 74 per cent of the United States total. The Midwest states, notably Oklahoma, Kansas, and Illinois, have 14 per cent of the gas reserves, whereas the West Coast has 8 per cent. The East Coast, the third largest consuming area, has only 3 per cent of the reserves whereas in the early-day history of the industry this district had the only gas reserves. Total gas production has shown a gradual and consistent increase over the last 25 years. It is estimated that approximately 5¼ trillion cu. ft. of gas were produced in 1945-1944; 4 trillion in 1943, and about 3½ trillion in 1942. This difference in production and the consumption mentioned hereinbefore is due to the field use of gas and supply for carbon black and chemical manufacture.

Fig. 3 shows gas reserves in Texas Railroad Commission districts and divisions in other states within PAW District No. 3. Table 1 is a comparison of gas-condensate reserves showing increase and per cent change in the 2-year period from January 1, 1943, to January 1, 1945. The largest gas district in Texas and possibly the largest in the United States is the Panhandle-Hugoton area, Railroad Commission District 10. Despite previous tremendous withdrawals and the many transmission lines emanating from this area, total proved natural gas reserves are still nearly 25 trillion cu. ft. This reserve is limited to the Hugoton, Texas, side only as the Hugoton field as a whole has an approximate reserve of about 25 trillion cu. ft. The Panhandle field currently produces about 2½ billion cu. ft. daily with 1½ billion exported by the major lines. Railroad Commission District 3, the Houston area, contains in excess of 18 trillion cu. ft. and ranks second in the Southwest. A greater portion of the reserves in this district are associated with oil either in the oil reservoir or in the structure. Ranking third is South Texas, Railroad Commission District 4, which had nearly 11 trillion cu. ft. proved. This area also is undergoing a very active development and exploration program and it is reasonable to expect that additional gas reserves will be developed henceforth. South Louisiana reserves are nearly comparable to South Texas, District 4, and should likewise experience substantial additions to the gas reserves due to similar exploration and deep drilling. Railroad Commission District 6, including the recently discovered Carthage gas field, ranks fifth in PAW District 3. This area also includes Long Lake-Cayuga and Rodessa fields. Recent exploration to the Travis Peak and accelerated exploration in the East Texas basin promises to increase these reserves further.

The West Texas area, Railroad Commission District 8, probably will develop more reserves and show a marked increase within the next few years, for recent extensions to old fields and deeper drilling to the Ellenberger have shown major gas-condensate reservoirs. This area promises to be most attractive for pipe line gas purchases.

Table 2 is a list of the major gas fields within PAW District 3 limited to those fields that are considered to contain a recoverable gas reserve in excess of 1 trillion cu. ft. as of January 1, 1945. It is significant that 14 fields fall within this category with a total recoverable gas reserve of 54.6 trillion cu. ft., representing 57.3 per cent of the recoverable gas reserves for the entire area, and approximately 40 per cent of the total gas in the United States. Ten of these fields are considered to be major gas-condensate reserves and the other 4 are predominantly dry gas.

The significance of gas-condensate discovery rates in the current overall exploration for oil is shown by Fig. 4.* It is indicated that along the Gulf Coast Plain of Texas approximately 41 per cent of the fields discovered in 1945 may be considered to be gas or condensate fields. In 1944, 51 per cent of the fields discovered in this area were gas condensate. With this increased ratio of gas-condensate discoveries, which has

TABLE 1—Comparison of gas-condensate reserves, PAW District No. 3, showing increase and per cent change.

Area	Recoverable gas reserves, millions of cu. ft.			
	January 1, 1943	January 1, 1945	Increase	Per cent change
Arkansas, North	52,873	43,195	9,678 (r)	..
Arkansas, South	872,312	840,443	31,869 (r)	..
Arkansas, total	925,185	883,638	41,547 (r)	
Louisiana, North	4,389,807	4,471,488	81,681	2
Louisiana, South	7,259,837	10,728,102	3,468,265	48
Louisiana, total	11,649,644	15,199,590	3,549,946	30
Mississippi	6,429	1,595,177	1,588,748	..
New Mexico	2,417,892	2,825,629	407,737	17
Texas, Railroad Commission 1	116,007	153,617	37,610	32
2	4,069,713	5,145,629	1,075,916	26
3	19,428,918	18,371,143	1,057,775 (r)	6 (r)
4	8,942,294	10,772,734	1,830,440	20
5	546,022	604,113	58,091	11
6	3,144,529	7,648,467	4,503,938	144
7B	232,518	324,079	91,561	39
7C	136,998	179,364	42,366	31
8	4,045,356	6,381,180	2,335,824	57
9	255,169	457,972	202,803	80
10	22,762,000	24,947,280	2,185,280	10
Texas, total	63,679,524	74,985,578	11,306,054	18
PAW District 3, total	78,678,674	95,489,625*	16,810,951	21

*Includes Florida (13).

shown a gradual increase as the depth of wells became greater, it is safe to assume that as deeper drilling depths are attained, more and more gas-condensate fields will be discovered in the future.

The logical source of supply to meet increased consumer demand dictates connecting the large reserve areas for transporting gas to industrialized sections. In order of rank, 4 areas offer attractive gas sources for such expansion. These are: Panhandle-Hugoton, Texas Gulf Coast, South Texas, and South Louisiana. West Texas has future possibilities due to current exploration and the recent development in treating technique whereby sour gas can be processed to meet pipe line standards. The East Texas-Carthage area has already experienced some pipe line expansion offsetting the decline of the Monroe field reserves, and a line to Ohio has been announced in addition to the possibility of converting the Big Inch and Little Big Inch pipe lines for gas.

● **Gas transmission systems.** The technique of transporting natural gas through long high pressure transmission lines has had marked effect upon the petroleum industry in the last decade. This expansion can be better visualized by comparing the extent and scope of transmission lines within Texas in the early days to the comprehensive and complex transmission systems now existent. Prior to 1925, Texas was not a marketer but was an importer of gas, and it was not until after 1925 that Texas exported more gas than was brought into the state. Now Texas supplies about 25 per cent of all the gas produced for pipe line usage. Despite this current exportation, which is at an unprecedented high, Texas still imports nearly 40 billion cu. ft. of gas annually.

Study of a general map of gas transmission systems within PAW District 3 prepared July 15, 1945, shows that the foci of transmission networks in the Southwest are: Panhandle-Hugoton, Monroe in North Louisiana, West Texas-New Mexico, and along the Texas Gulf Coast. It may be expected that with the exception of the Monroe area, these other areas may continue to be the major origination points for new lines. Obviously, the new lines must connect or be predicated on gas reserves as now proved. Certain major systems now emanate from these areas; for instance, in

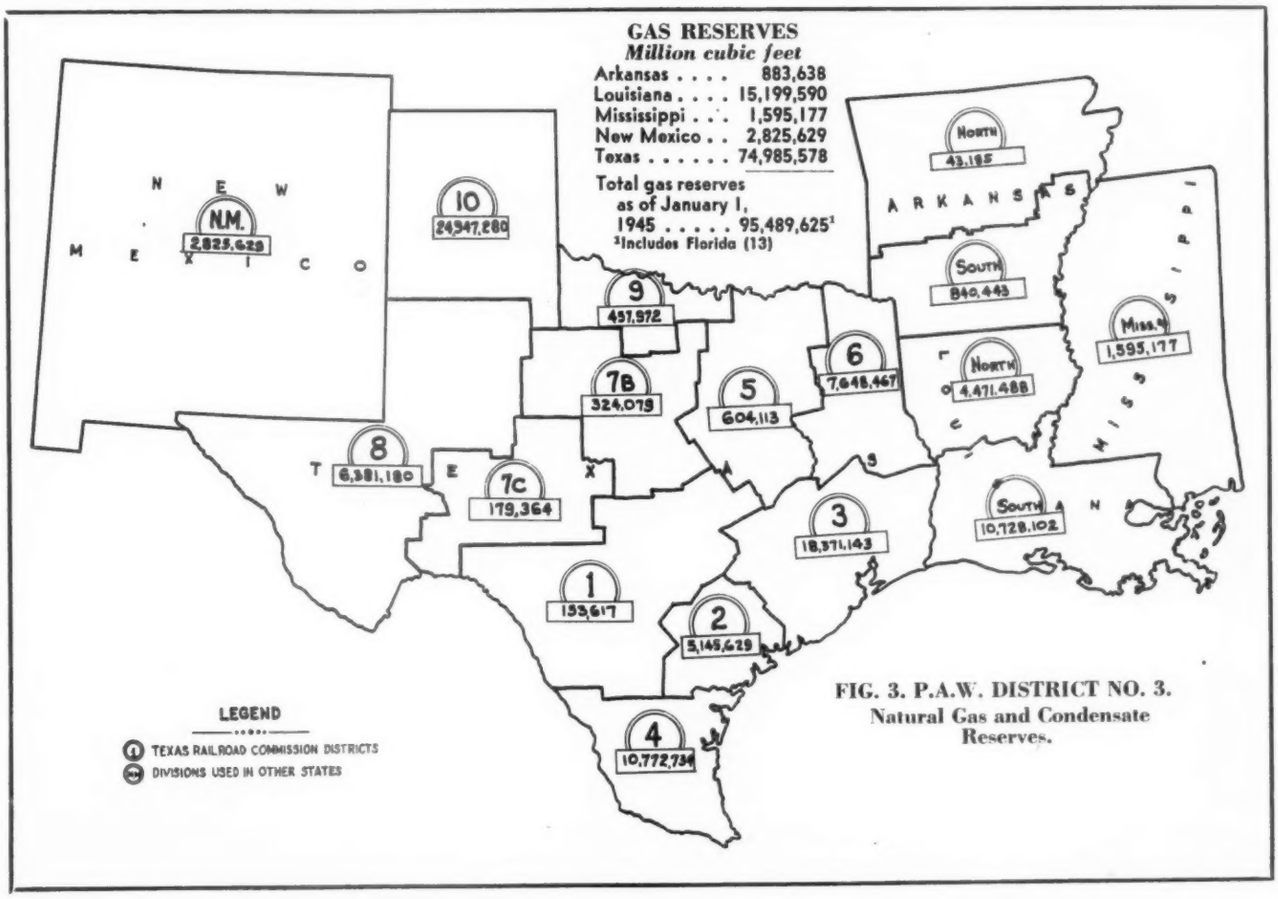
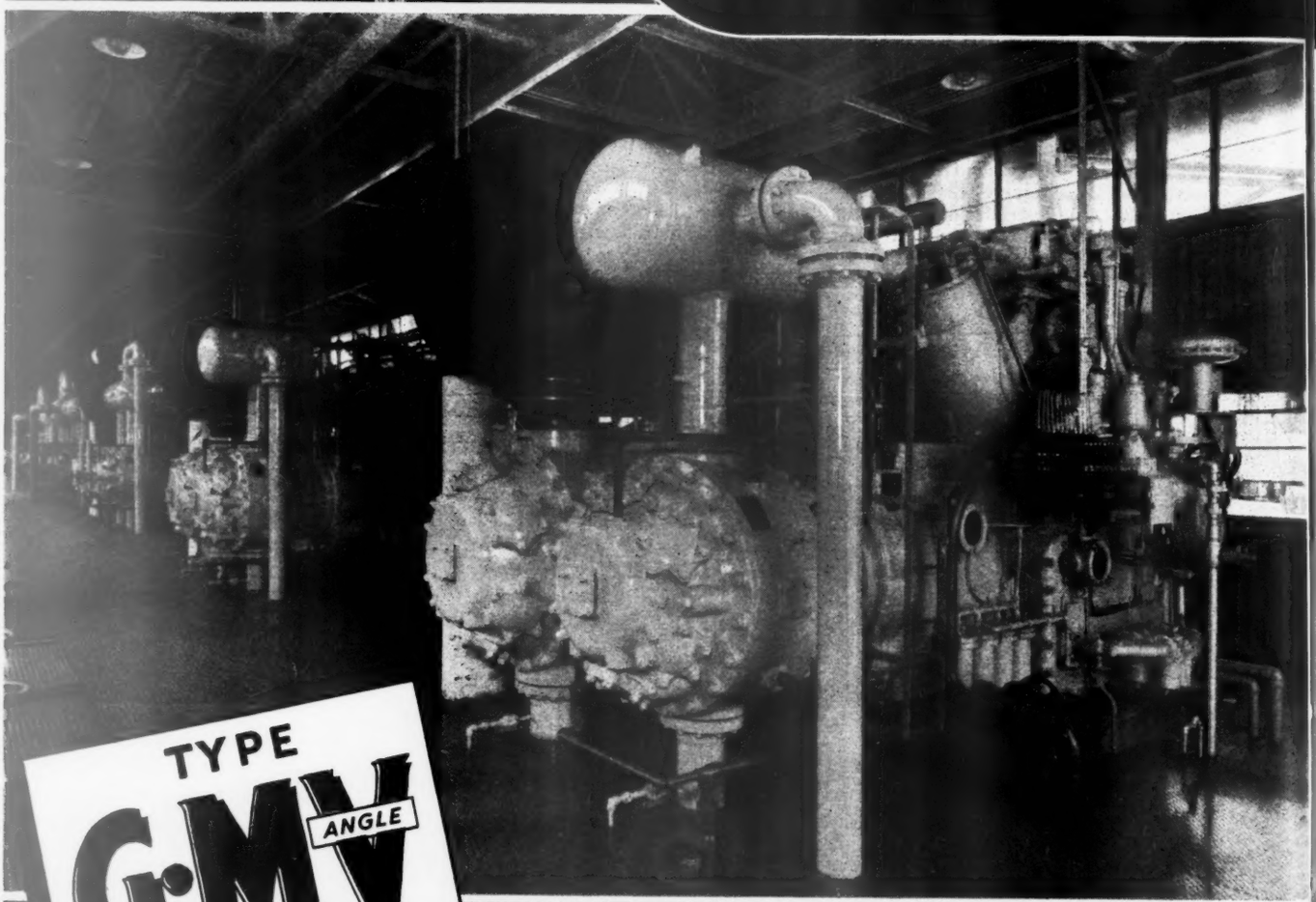


FIG. 3. P.A.W. DISTRICT NO. 3. Natural Gas and Condensate Reserves.

GMV compressors in the Dow Styrene Plant total 4,400 horsepower, are shown here from the crankdoor side. The two GMV's in foreground are six-cylinder units, each rated 600 hp. Third compressor is an eight-cylinder, 800-hp ammonia unit.

Exterior view of compressor building at Dow Styrene Plant, Los Angeles, California, showing exhaust silencers, intake air cleaners and air storage tanks.

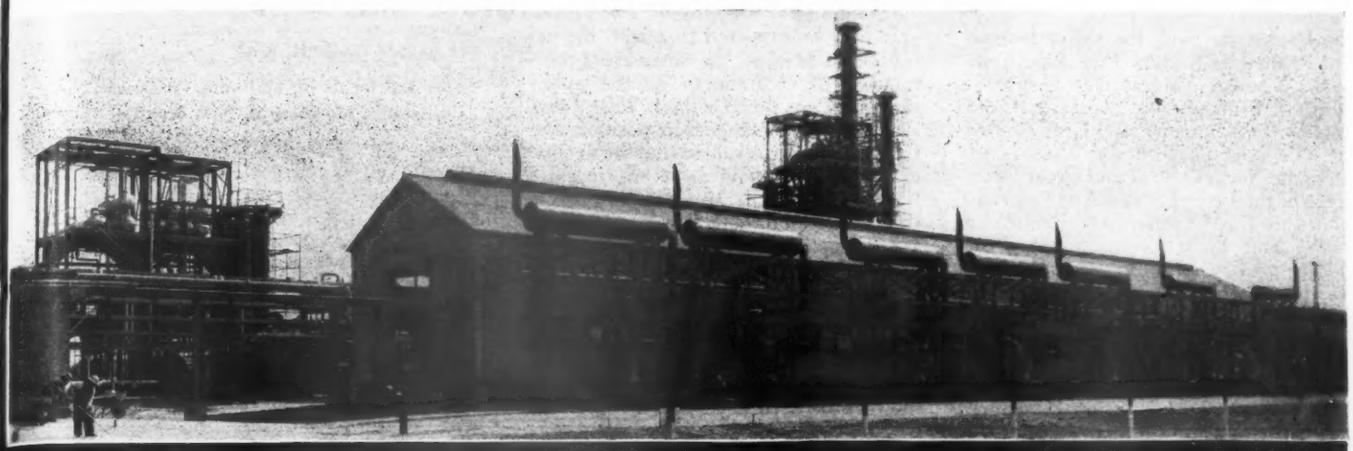
GMV "angles"



TYPE GMV ANGLE

Compressors

New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Cal. Seattle, Wash.



for the Products of Tomorrow

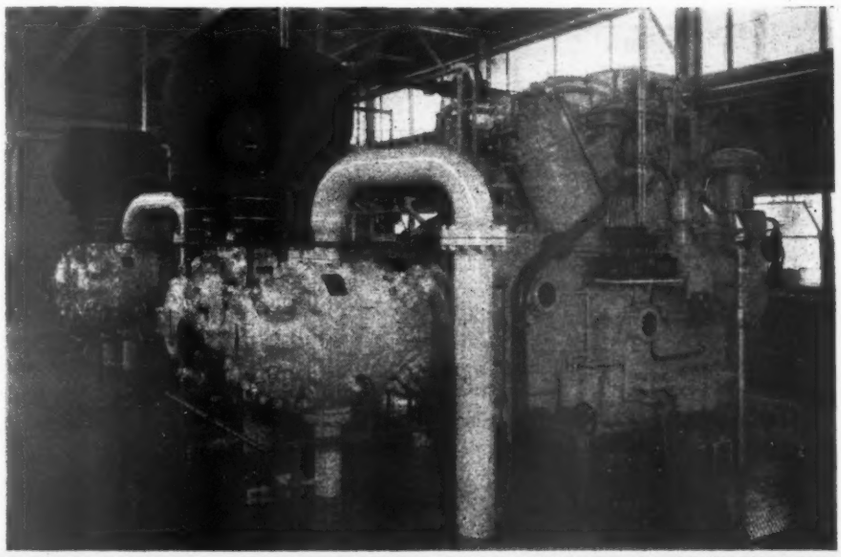
At The Dow Chemical Company's Styrene Plant, Los Angeles, California, seven modern GMV compressors help produce monomeric styrene as well as several other products, all having important peacetime applications.

As always, selection of compact, rugged GMV's made possible an economical and highly practical compressor setup. For example, fast, positive response to sensitive control instruments has been highly developed in the GMV, making it particularly desirable for modern processing requirements. Responsiveness is only one of the many phases of operation in which the GMV excels. Likewise there are exclusive features of design and construction that have helped earn for this modern 400, 600, 800 and 1000 hp compressor a reputation for truly exceptional service and performance.

The GMV Bulletin, 48 pages of data and interesting information, will be mailed in response to your request.

The seven GMV compressors installed in the Styrene Plant of The Dow Chemical Company are here shown from the compressor cylinder side. The fourth and fifth GMV's are eight-cylinder, 800-hp feed gas units. Compressors six and seven in this interesting line-up are GMV four-cylinder ethylene units.

Close-up of the two GMV-4 400-hp ethylene units showing compressor cylinders, piping and control equipment.



by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Houston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles

the Panhandle field, the major systems are Panhandle Eastern Pipe Line Company, Texoma Natural Gas Company, Northern Natural Gas Company, Cities Service Gas Company, and Consolidated Gas Utilities Corporation. These lines serve the North Central and Great Lakes areas of the United States. The Colorado Interstate Gas Company and Panhandle Power and Light Company serve the Denver area, whereas the United States Gas Pipe Line Company and Lone Star Gas Company transport gas to the central part of Texas. The West Texas Gas Company traverses West Texas. Along the Texas Gulf Coast the United Gas Pipe Line Company, the Houston Pipe Line Company, and the recently constructed Tennessee Gas and Transmission Company are considered the major systems.

The Monroe area is another point of origination for many major gas transmission lines. This field until recent years was the second ranking field in the United States but due to exportations and gas withdrawals has declined to a current reserve of about 1¼ trillion cu. ft. It is still a vital origination point for the following gas transmission lines: Mississippi River Fuel Corporation, to St. Louis, Memphis Natural Gas to Memphis, Southern Natural Gas Company to Birmingham and adjoining areas, the Arkansas Louisiana Gas Company to Arkansas, the United Gas Pipe Line Company across North Louisiana into East Texas, and the Interstate Natural Gas to Baton Rouge connecting with the United Gas Pipe Line system.

It may be expected that with the exception of Monroe, the other areas mentioned will continue to be the major sources of gas for new lines. West Texas should show a stepped-up position and Carthage is already offsetting the decline of the Monroe field as it has recently been connected to Monroe. The Texas Gulf Coast and South Louisiana will offer attractive supply sources due to proved reserves and the tendency of new development to discover increasing numbers of gas-condensate fields.

● **Major gas projects.** Major gas projects as now announced or contemplated for construction during 1946 have been shown on Fig. 5. The El Paso Natural Gas Company's 720 miles of 26-in. gas line from Jal, New Mexico, to Blythe, California, where it will connect with a 214-mile 26-in. gas line from Blythe to Santa Fe Springs proposed by Southern California Gas Company and Southern Counties Gas Company is a significant development for the West Texas-New Mexico area. The El Paso portion of this line is to have an initial capacity of 125 million cu. ft. a day to a maximum of 325 million cu. ft. a day, and will cost about $25,000,000. This new system will obtain gas from Dumas in the Panhandle field and from the Fullerton, TXL and Keystone Ellenberger fields in West Texas. It will collect sour gas, which has hitherto been wasted and unusable, to process the casinghead gas for delivery to the State of California.

Another major system for the Panhandle is the proposal by the Michigan-Wisconsin Pipe Line Company to construct 1216 miles of 22-in. and 26-in. natural gas line from the Hugoton field, Texas and Oklahoma, to the Austin Storage field in Michigan. This line will cost approximately $70,000,000 and deliver natural gas to an area that is highly industrialized and is a good market prospect. Considerable opposition may arise to the proposal, for it will further invade a highly industrialized coal consuming area.

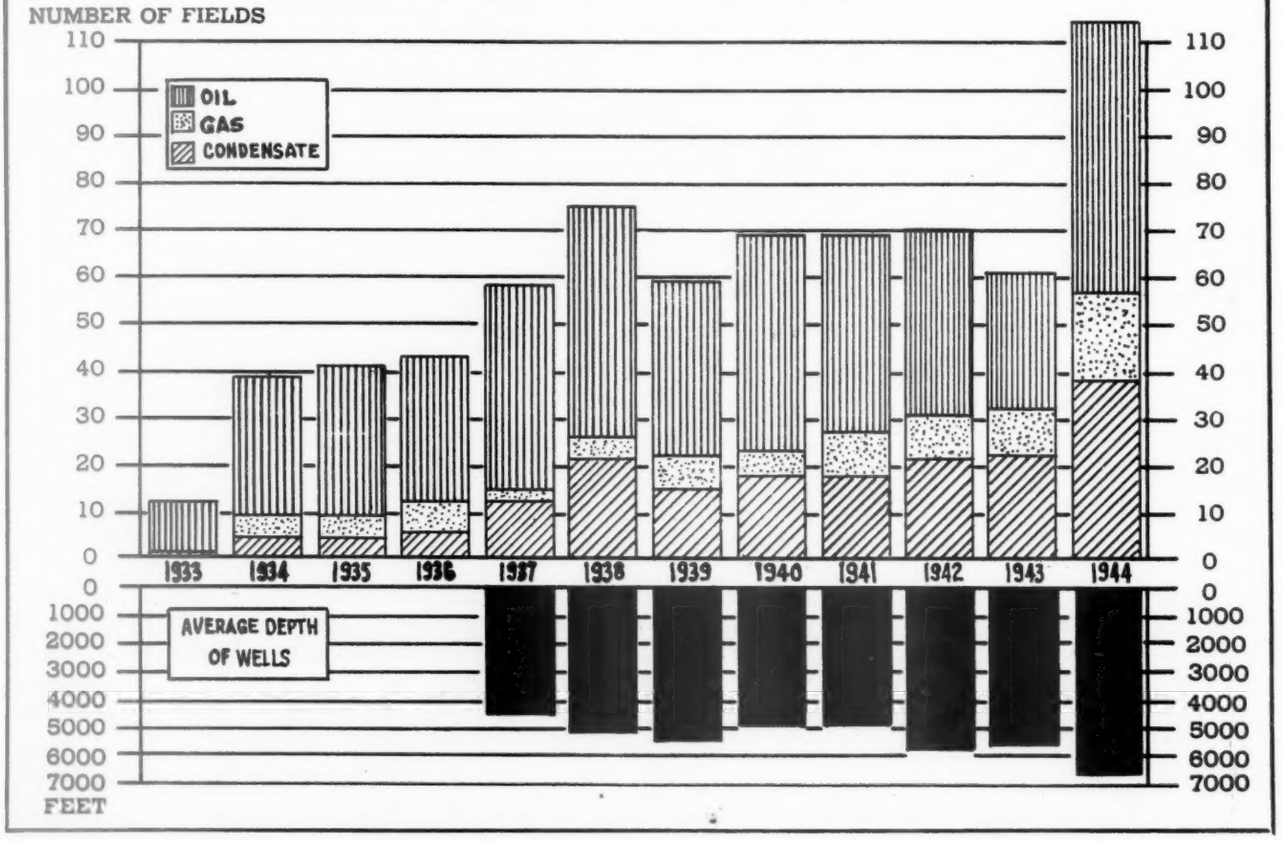
The United Gas Pipe Line Company has recently completed 143 miles of 24-in. line, which under field pressure of

TABLE 2

Major gas fields in Alabama, Arkansas, Louisiana, Mississippi, New Mexico, and Texas.

Rank	State	Recoverable gas reserves, trillions of cu. ft. January 1, 1945
	Texas:	
1	Panhandle	19.0
2	Hugoton (Texas only)	5.7
3	Katy	6.2
4	Carthage	6.0
5	Old Ocean	3.5
6	Agua Dulce and Stratton	3.4
7	Sheridan	2.1
8	Pledger	1.7
9	La Gloria	1.4
12	Seeligson	1.1
	Louisiana:	
10	Erath	1.3
11	Monroe	1.2
13	Paradis	1.0
	Mississippi:	
14	Gwinville	1.0
	Total major fields—14	54.6
	Total all fields	95.5
	Per cent of reserves in these states	57.3

FIG. 4. CONDENSATE DISCOVERY RATE TO BE REVIVED
South Arkansas — Louisiana — Texas Coastal Plain



1000 lb. per sq. in. at the Carthage origin delivers gas to Monroe for sale to Mississippi River Fuel, Memphis Natural, Southern Natural, and Tennessee Gas and Transmission Company. This to offset the declining reserves of the Monroe field and to augment Tennessee's supply to West Virginia.

Another proposed trunk line to originate in the East Texas-Carthage area is the Metropolitan Eastern Corporation, which proposes to lay 825 miles of 18-in. natural gas line to deliver natural gas to Hamilton, Ohio. This line is still in the planning stage.

Tennessee Gas and Transmission Company has an application before the Federal Power Commission for an extension of its system from the Agua Dulce-Stratton area to the San Salvador field. This would require 95 miles of 16-in. line with a capacity of 100 million cu. ft. a day, costing about $2,500,000.

Another major line that may possibly revert to its original usage is the Southwest Emergency line, once a part of United Gas Pipe Line Company's system but during the war converted for crude oil, consisting of 184 miles of 14-in. and 16-in. line, which could augment present deliveries to the Houston area and might provide a major lateral for the Little Big Inch conversion. This line traverses or is adjacent to several of the major gas-condensate reservoirs.

The forecast of about 5000 miles of gas transmission construction during 1946 assumes that a majority of the applications will be granted by the Federal Power Commission and that adequate material can be obtained in sufficient time to complete the programs.

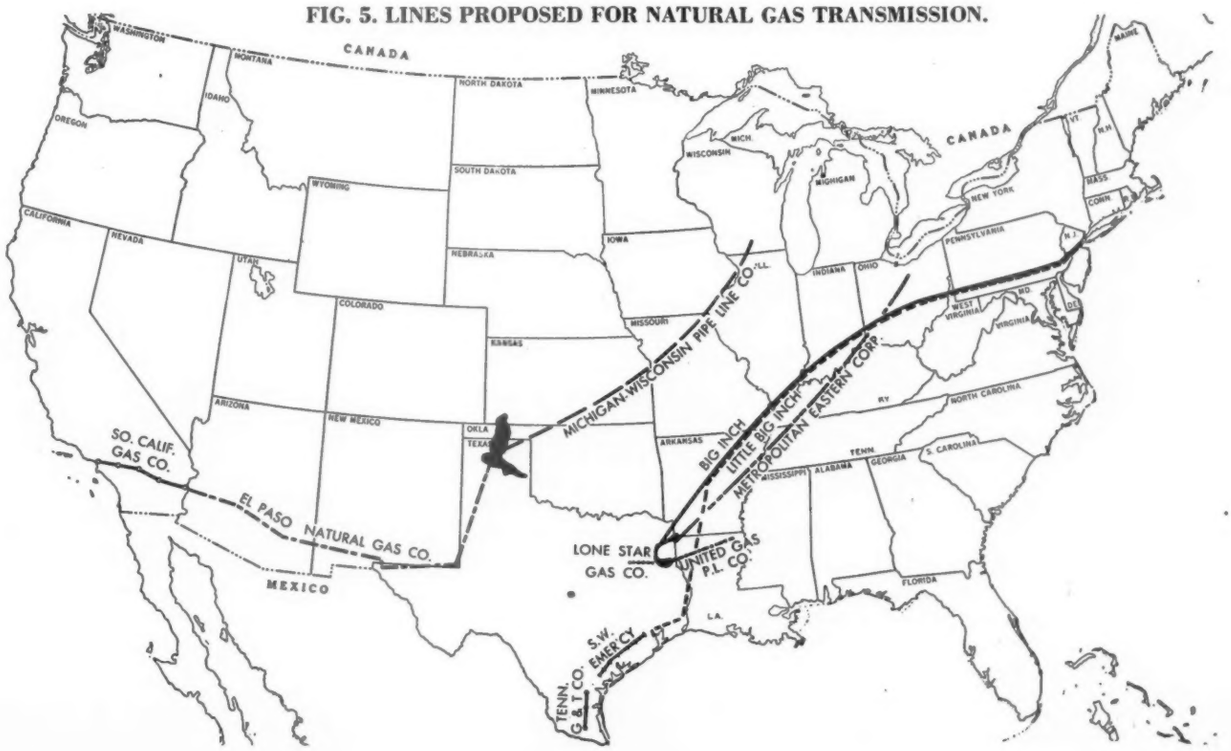
● **Big Inch and Little Big Inch lines.** Conversion of the Big Inch and Little Big Inch pipe lines for transporting gas would be a very significant development to the oil and gas industry and would have profound effect upon the present low wellhead price of both dry and casinghead gas. Current discussion of this conversion remains controversial with many proposals and recommendations offered. The Big Inch line, consisting of 1254 miles of 24-in., cost $78,500,000, and the Little Big Inch, formerly used for products, consists of 1475 miles of main line costing $60,000,000. The Big Inch originates near Longview in East Texas and its terminus is Linden, New Jersey, in the heart of the Metropolitan area of the Eastern Seaboard of the United States. It is estimated this area embraces a population of more than 13,000,000 with about 3,500,000 gas consumers who currently pay approximately $1.00 per M. cu. ft. for 520-540 B.t.u. manufactured or coke oven gas. This is equivalent to $1.85 per M. cu. ft. for natural gas. The potential market could readily absorb without severe dislocation the capacity of either or both lines, which are capable of transporting nearly 500,000,000 cu. ft. a day while operating at 700 lb. per sq. in. At a 75 per cent load factor, these lines would export from Texas about 2½ trillion cu. ft. in 25 years, which is a small per cent of the present total proved gas reserves of the country. It is envisioned that the lines would supplement the present fuels permitting some enrichment and possibly save about 10,000,000 bbl. of fuel oil annually by those companies now using oil for manufactured gas.

Recently, cost and earning estimates have been made that indicate these lines cannot be operated by private interests unless sold at a reduced cost of $80,000,000, with a further gas conversion cost of $30,000,000. This assumes a wellhead price of about 6 cents with a delivered cost to the Metropolitan area of approximately 26 cents, 30-year depreciation, and a limited 6½ per cent earning on the capital investment.

The availability of gas at these lines' origin appears sufficient in the broad view but considerable pipe line extensions to the aforementioned East Texas and Gulf Coast reserves would be necessary. Past trends of lower and lower city gate prices in the East may act as a deterrent to conversion of these lines for gas, particularly when there is rising pressure in Texas for a wellhead price increase of gas concurrently with great opposition by the railroad and coal interests to continued invasion of industrial markets. One of the distinct advantages for the Eastern Seaboard gas companies would be to admix natural gas with manufactured gas for enrichment purposes and effect an expansion of the present overloaded gas distribution systems in the various cities. No doubt, industrialists and investment companies in the East will look with favor upon the conversion but due to the political aspect of such conversion and the present unknown factors, considerable time may elapse before a clear picture of the lines' ultimate use will emerge.

● **Chemical syntheses.** The chemical syntheses of natural gas, excluding carbon black manufacture, should have little effect on the gas transmission business as a whole, for the total volume of gas required for conversion is relatively small, representing about 1 per cent of the natural gas currently consumed. The usual raw feed for chemical manufacture is the ethane-propane

FIG. 5. LINES PROPOSED FOR NATURAL GAS TRANSMISSION.



fraction rather than the methane hydrocarbon required for pipe line usage. As higher yields can be obtained from the ethane-propane-butane fractions and the total chemicals manufactured at the present time are obtainable from about 600 billion cu. ft. of gas, it appears little competition will exist between chemical syntheses and the transmission business. An exception may be the Fischer-Tropsch conversion, which promises to develop on a commercial scale in the near future. Many articles and much publicity have dealt with this subject. Extensive pilot plant operation is currently under way and a plant location has been tentatively announced for Texas. The Fischer-Tropsch Synthine or Hydrocol process is a catalytic conversion of methane wherein liquid fuels, principally motor gasoline, high cetane diesel oil and wax, can be produced by catalytically cracking methane gas under controlled temperatures and pressure in the presence of suitable catalysts. Much promise is offered by this utilization, for it has been used extensively in Europe and technologists are working intensively to prove its economic success. At present it cannot compete with the improved catalytic cracking refinery methods until the price of crude oil reaches about $1.75 to $2.00 a bbl. It may be competitive for the production of high cetane diesel oil and certain selective intermediate chemical raw materials.

The great publicity and scientific aspect of liquid fuel production from natural gas has tended to strengthen the wellhead price of natural gas in the field. It has captured the public fancy and the eventual result may be that the general public and the petroleum industry will become more conscious of the need for improved gas conservation, particularly when such a forward scientific development places a tangible value on gas that at the present time cannot be utilized for other purposes.

● **Federal Power Commission.** The Federal Power Commission's gas investigation in the several states wherein relevant information is being submitted by the oil and gas industry and others springs from recent trends by the Federal Power Commission toward the control of end use of natural gas in competition with other fuels in the industrialized areas. The Federal Power Commission regulates the price of gas to the consumer when natural gas moves in interstate commerce, and through the issuance of Certificates of Convenience and Necessity has delved into the matter of natural gas reserves, cost of production, size, capacity and engineering features of new lines and almost every conceivable question in the development of new transmission systems. The lack of clarification of certain provisions of the Natural Gas Act, together with the apparent ultimate aim of the Federal Power Commission to decrease the cost of gas to the consumer, has created considerable consternation in the oil industry itself. The prompt establishment by the Federal Power Commission of explicit standards for issuance of a Certificate of Convenience and Necessity for new lines would greatly improve the present situation. It appears that certain points of ambiguity in the Natural Gas Act should be clarified. If this can be accomplished, oil and gas producers may achieve higher field prices for the gas, the petroleum industry can take broader steps virtually to eliminate the current wastage of oil well gas, and overall good may be attained. At the present time, depressed field prices of gas is the indirect result of the stringent requirements for a Certificate of Convenience and Necessity. Very often a gas transmission company is precluded from picking up oil well gas even though the gas may be nearby and a desirable source of supply to the system's reserves. It is not possible to predict what the future will bring in the way of improvement of natural gas prices and markets; however, when favorable markets appear, prices move upward and wastage of gas is eliminated.

● **Conclusion.** In conclusion, based on a review of the reserves, the recent war period expansion of transmission lines, and new construction as now announced, the following observations may be made:

1. Proved natural gas reserves are adequate for a reasonable market expansion. This expansion is impendent, for several large transmission lines are taking steps to increase their current capacities.

2. Gas pipe line companies have instituted ratable takes in certain areas and this practice will ultimately receive universal acceptance. In the near future, gas transmission lines will be urged either by public opinion or regulatory authority to take greater quantities of oil well gas in order to reduce current gas wastage to a minimum. It may be possible in certain long high pressure lines operating with high load factors to achieve a load inversion whereby oil well gas will become the base gas transported and the pipe line can meet peak demands through supplemental dry gas from gas reservoirs. This trend has been more pronounced since the war period but ultimate fulfillment of such a goal will be slow, for such an operation creates the question of equities between oil and gas reservoirs and within the areas from which the pipe line procures its supply of gas.

3. The gas transmission business, after a very hectic birth, has become a stable and substantial part of the economic life of the Nation. Its flexibility is limited due to the fugacious or peculiar nature of gas, which cannot move as a commodity but must be delivered from well to consumer when and as needed.

4. The adoption of proper gas well spacing within fields and the growth of gas proration rules promise to become more widespread and necessary in the near future.

5. The development of gathering and improved treating techniques wherein sour or sulphur gas, previously useless and unwanted, will promote and help conserve substantial quantities of gas and increase the availability of such oil well gas to transmission lines.

6. The continued and successive increased demand for natural gas should be an incentive for producers to conserve gas and should bring about a higher price at the wellhead. This may be occasioned by new markets either for carbon black, transmission usage, chemical syntheses for liquid fuels, or for pressure maintenance to attain maximum oil recovery. The possibility of producing gasoline from methane offers a great incentive to the owners of both dry and oil well gas because gas prices can only move under competition or through the law of supply and demand. The consumer of natural gas is interested not only in the present price of gas but in the continuity of supply over a long period of years. It would be fallacious and unworkable to control the end use of this energy source without likewise recognizing coal, fuel oil, electric and water power, and others in the overall energy resource pictrue.

The future outlook for gas transmission lines with concurrent increased prices at the wellhead is as bright if not brighter than it has been in the recent past. The rapid development of transmission technique wherein larger lines can be constructed economically should enable gas transmission companies to deliver natural gas to consumers at attractive prices. The development and application of scientific research wherein gas can be utilized for all types of energy promises to contribute much to the general welfare of the public and the petroleum industry alike. It appears constructive good will be the outcome from the current investigation as it will enable the public to recognize the scope of gas transmission operations and see the real need for guaranteed continuity of service. Low gas prices tend to discourage conservation of this energy resource and in the present period of conservation, based on sound engineering, normal economic forces should be allowed to establish the proper level of gas prices in relation to other competitive values. The gas transmission business currently renders a public service for the enjoyment and betterment of the Nation and if not unduly hampered through artificial regulation of prices can henceforth mutually resolve the gas wastage of the oil industry and make available this convenient fuel to a larger number of consumers. ★★★

World's largest gasser

Skelly Oil Company's No. 1-D Werner in the eastern edge of the huge Carthage gas-condensate field of Panola County, East Texas (outside) fields, is the world's largest gas well according to field engineers of the Texas Railroad Commission. The test was drilled to 6240 ft., then backed up to 6185 ft. and the casing perforated from 5854-90 ft. Tests showed 480,000,000 cu. ft. of gas production.

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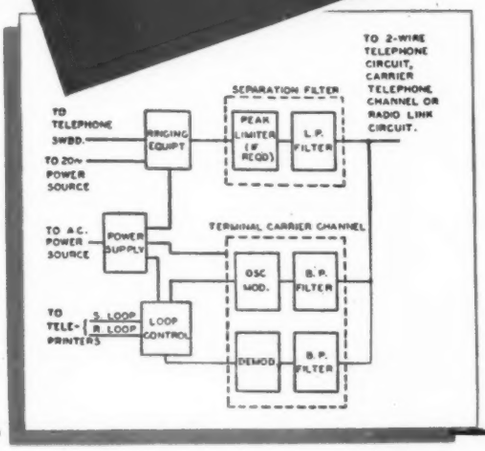

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UNITIZED PORTABLE COMPRESSOR PLANT AS USED FOR PRESSURE MAINTENANCE

By **F. L. KALLAM,** *President,* Industrial Engineers, Inc.

IT IS well to remember that the present average cost of discovering, developing, and producing new reserves in this country is greater than the selling price of the resulting new crude oil. Obviously, a barrel of extra oil, even at a relatively high production cost, is more profitable than that which may be discovered after a string of dry holes. Thus secondary recovery efforts to obtain additional oil from established reserves is of utmost importance. Probably the most important of all such methods are the gas injection processes to formations where the primary recovery forces are fast being depleted.

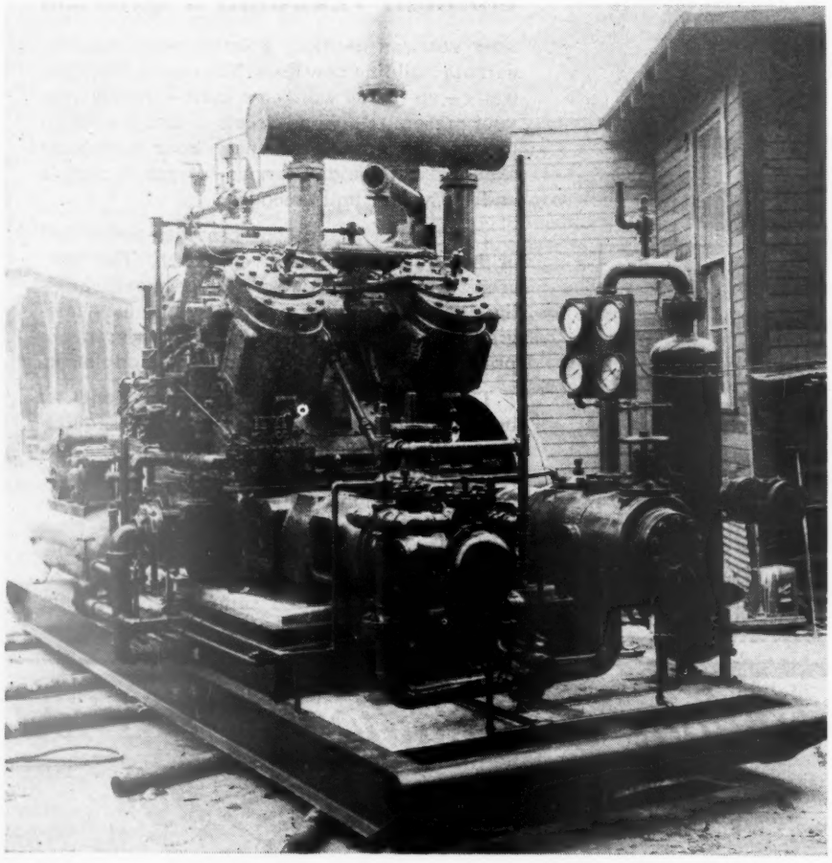
EXCLUSIVE

From the best available sources it appears that 70 per cent of the active wells in the United States are produced by pumping or other artificial lift. Thus 70 per cent of our oil production comes from fields where the natural reservoir energy has been almost depleted and yet we have recovered but 25 per cent of the oil available in the ground. What is required to protect our national oil supply are methods that produce at the most effective rate and yet make it possible to meet actual market demand. It is now believed that an operating procedure that includes the return of the gas produced with the oil back into the producing formation offers the best opportunity of achieving economic yields. This conclusion follows results from existing pressure maintenance projects and from studies of proposed installations. In most instances, the desirability of pressure maintenance over primary recovery methods is evidenced by the following.

1. **Oil recovery is 10-50 per cent greater.**
2. **Total lifting cost is 10-20 cents a barrel less.**
3. **Capital investment is about equal to artificial lift under primary recovery.**

Unfortunately, there is no way to foretell positively whether the installation of a pressure maintenance system will follow this pattern. In fields where there is a lack of reservoir data, well records, and possibly some unfavorable indications, the installation of a complete pressure maintenance plant may be questionable. In these cases the recent development of a completely unitized skid-mounted full-size compressor unit will prove of great value. Such a unit makes possible a conclusive test of pressure maintenance in a given area while risking only a fraction of the capital investment that has been necessary in the past.

Close-up of 150-hp. two-stage unit, prior to loading, 400 to 2000-lb. pressure.



This shop-fabricated compressor plant unit, in size, weight, and general construction greatly resembles one of the heavier pieces of unitized drilling equipment and in use it has the same advantages of mobility, economy, and salvage value.

The unit has been built in the 150-hp. size with 300 hp. available. The entire plant is packaged on an integral base occupying a ground space of 9 ft. wide by 21 ft. long. The overall height is approximately 11 ft. One such unit, weighing 30 tons, was loaded at the factory in the morning, transported 200 miles and placed in operation the following afternoon compressing more than a million cubic feet of gas per day from 450 lb. to a final discharge pressure of 2500 lb. per sq. in.

All necessary auxiliaries to the compressor are provided, including a gasoline engine-driven air compressor with necessary storage for starting the main engine compressor. It provides a jacket water cooler of the air type, driven from the main gas engine, as well as a water circulating pump powered from the same source.

The cooling of the water is sufficient

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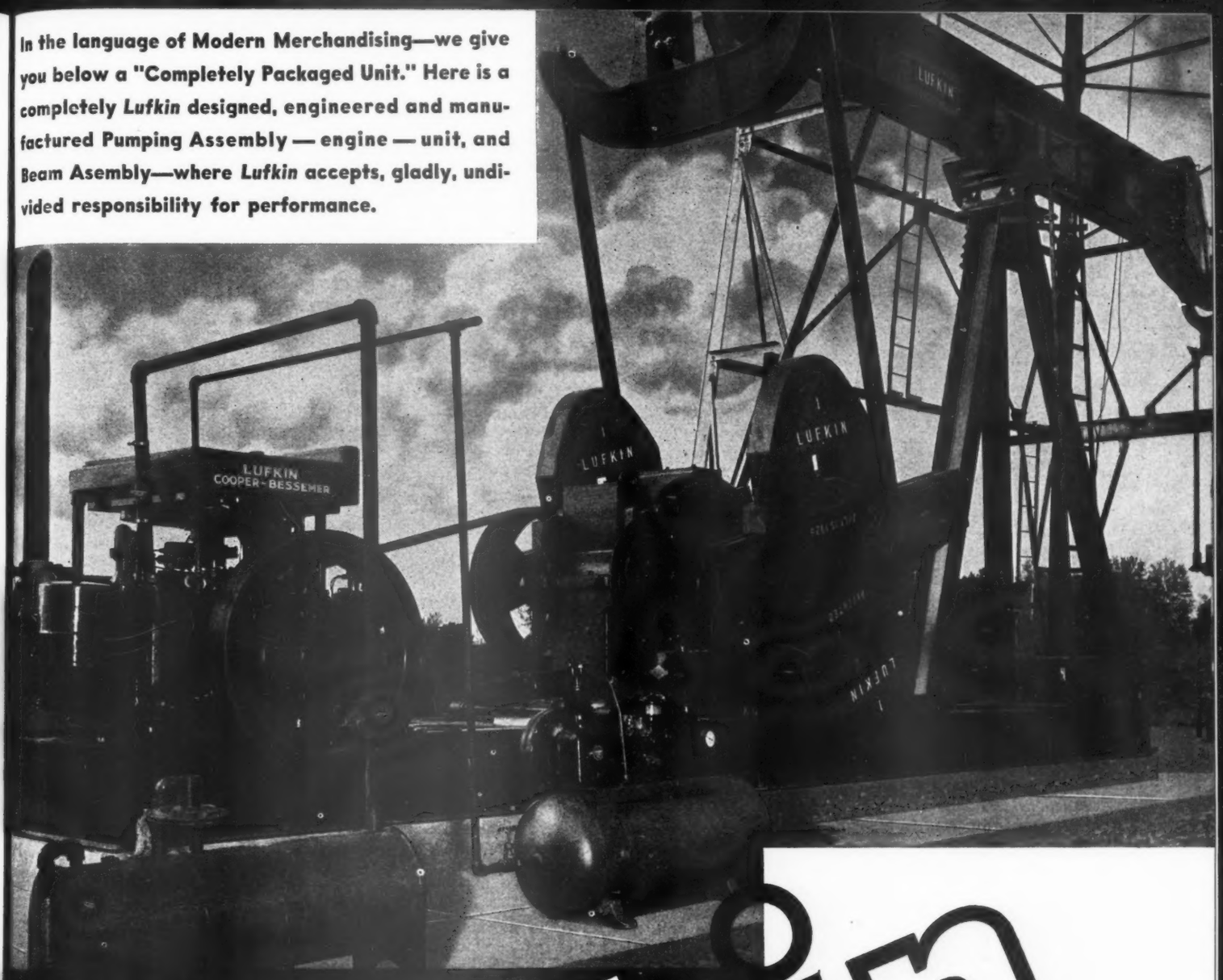

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Call our nearest engineer for consultation. There will be no obligation to buy.

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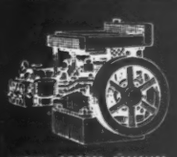

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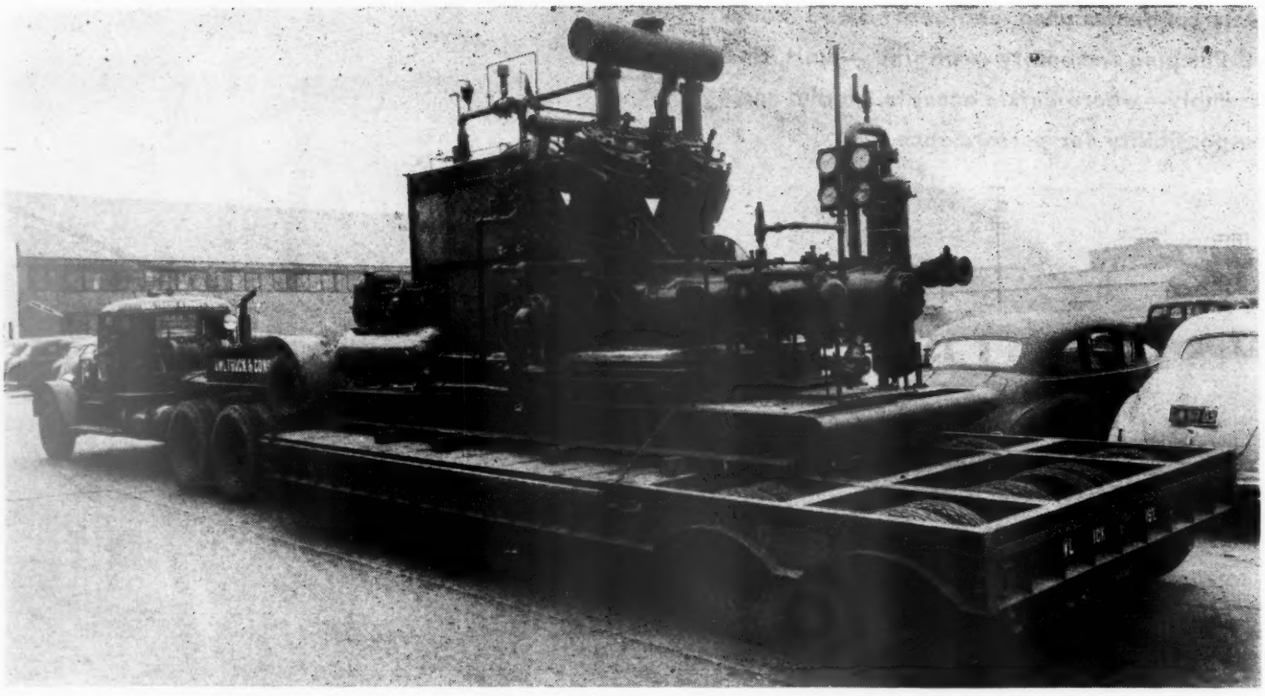


Loaded and on way to field is 150-hp. unit, weight about 30 tons. Air intake filter and muffler outlet removed for highway hauling.

to permit a portion to be circulated through an auxiliary cooler for the purpose of controlling the temperature of the lubricating oil to the main engine. A surge and supply tank also is incorporated into this jacket water cooling system. The engine compressor is provided with an overhead muffler, air intake filter with relief valve, gas fuel reducing regulator, and fuel capacity tank.

The compressor cylinders are piped as required for the service conditions, some installations being single stage, others two stage, and still others are manifolded to permit operation either way. The intake piping is provided with a scrubber for the removal of possible entrained liquid.

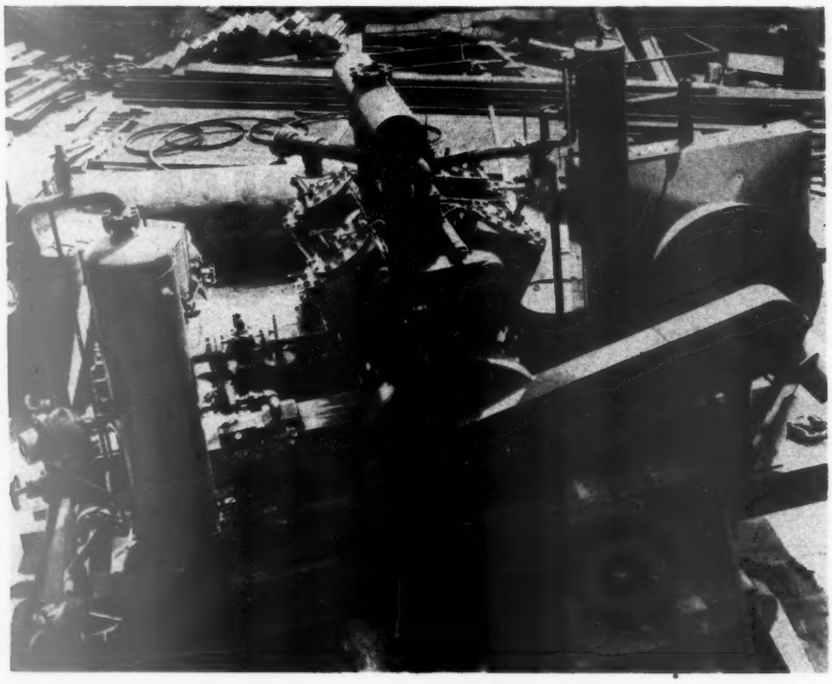
The unit as received in the field is completely and adequately piped for immediate operation even to including a gauge board with necessary instruments. After unloading the compressor unit and placing it on prepared level ground, the field crew has only to connect the inlet gas and outlet gas lines and begin operation. Each of these unit plants is operated at the factory prior to shipment so that only minor field engine adjustments are usually required. When desired, the unit is supplied with a structural steel housing that affords protection against the weather.

Although this unit was developed to handle temporary gas requirements as an individual unit, several can be placed alongside of one another to give almost any desired capacity. They can be manifolded together as in the conventional permanent compressor plant and operated in a similar manner. It is also very simple to make the units practically automatic so that they can be situated adjacent to input wells, or in remote locations, without requiring an operator. When used in this way, the units are about equivalent to the usual oil well pumping unit with regard to the amount of manual attention that they require.

Regardless of how such units are utilized, the fact remains that they are 100 per cent salvageable. They can be disconnected from one service and moved to other parts of the field as necessity dictates, or to other districts. No dismantling of equipment is required and no concrete foundations are left behind. They are particularly attractive to the small operator because of their economy and the ease with which they can be installed and operated by field personnel, and large companies have found them to be particularly useful for testing and for pilot operations.

★★★

Another 150-hp. unit, single stage, with intake scrubber fitted with automatic controls. Unit on cribbing ready to load. This shows rigidity of unit and how it can be handled with unskilled labor. Air intake filter and muffler outlet are removed.



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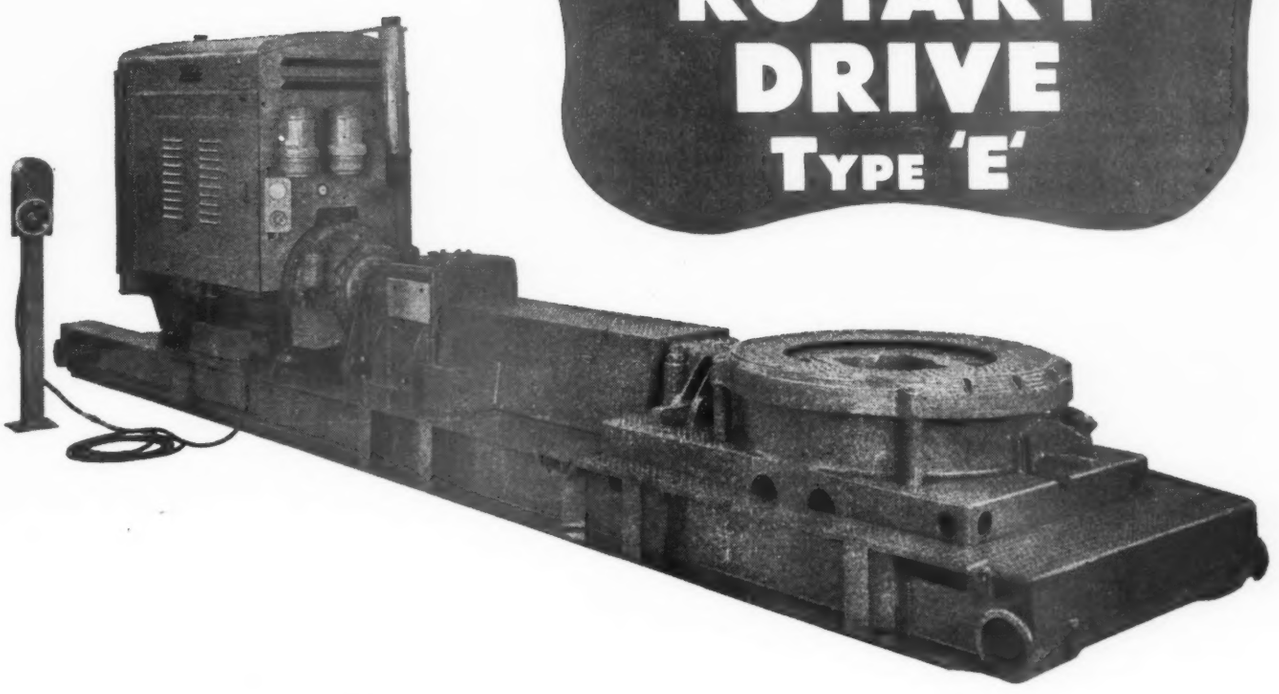
TYPE 'E'



This combination of an internal combustion engine, hydraulic torque converter, gear box and rotary provides additional power to the rig for drilling with full independent control of the pump and rotary.

Design of the drive permits installation under derrick or under any cantilever type mast.

The Ideal Types FE-17½ and MS-20½ rotaries are offered for mounting on this unit. Other rotaries of the proper gear ratio and shaft height may also be installed.

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DEEP TEST AT SIGNAL HILL

By **NICHOLAS A. D'ARCY, JR.**

SHELL OIL COMPANY, INC., drilled to 14,950 ft. on its Alamitos 48A location and penetrated the formations they set out to test. The completion of a well, originally scheduled to drill to 15.000 ft., in 14,950 ft. is a tribute to the accuracy of the data developed by the geological department, and the operating skill of the drilling department.

EXCLUSIVE

Shell was drilling Stakemiller-Rose No. 1, which penerated to 12,381 ft., at the same time as they were drilling Alamitos No. 48A. Both wells exceeded in depth any previous drilling operations at Signal Hill, and Alamitos No. 48A is not only the deepest hole drilled there but is also the deepest well drilled in the Los Angeles Basin.

Much of the hole was drilled with used pipe, and fishing time amounted to 10 per cent of the total elapsed time. The well was completed to 14,950 ft. with 3½-in. grade D drill pipe. Undoubtedly the project could have been completed with much less trouble and in a shorter time had Shell been able to obtain new grade E drill pipe for the deep work.

One drill pipe failure was responsible for a fishing job at 14,875 ft. The resulting operation terminated in a successful inside cutting job at a depth of 14,584 ft., which is likely the greatest depth at which an inside cutting has ever been performed satisfactorily. A special whipstock was permanently set upon the top of the fish, without being cemented in place, and the well was completed to its desired depth. The hole was in good condition when drilling operations ceased, and there was no stoppage because of mechanical trouble.

● **Early Signal Hill history.** This is not the first time Shell Oil Company, Inc., has been in the spotlight at Signal Hill. On June 25, 1921, this company completed Alamitos No. 1 at a depth of 2724 ft., as the discovery well of the Signal Hill field. This well established the producing formations on the south and east flank. On October 26, 1921, Shell also completed its Horsch No. 1 well to extend the productive area to the north and west flank of the Hill. Later Shell drilled Nesa No. 11 to 9280 ft., and unsuccessfully tested oil bearing formations between 9144 and 9280 ft. This well was one of the deep tests of its day and proved the location of oil-bearing sands at what had been considered an unheard of depth.

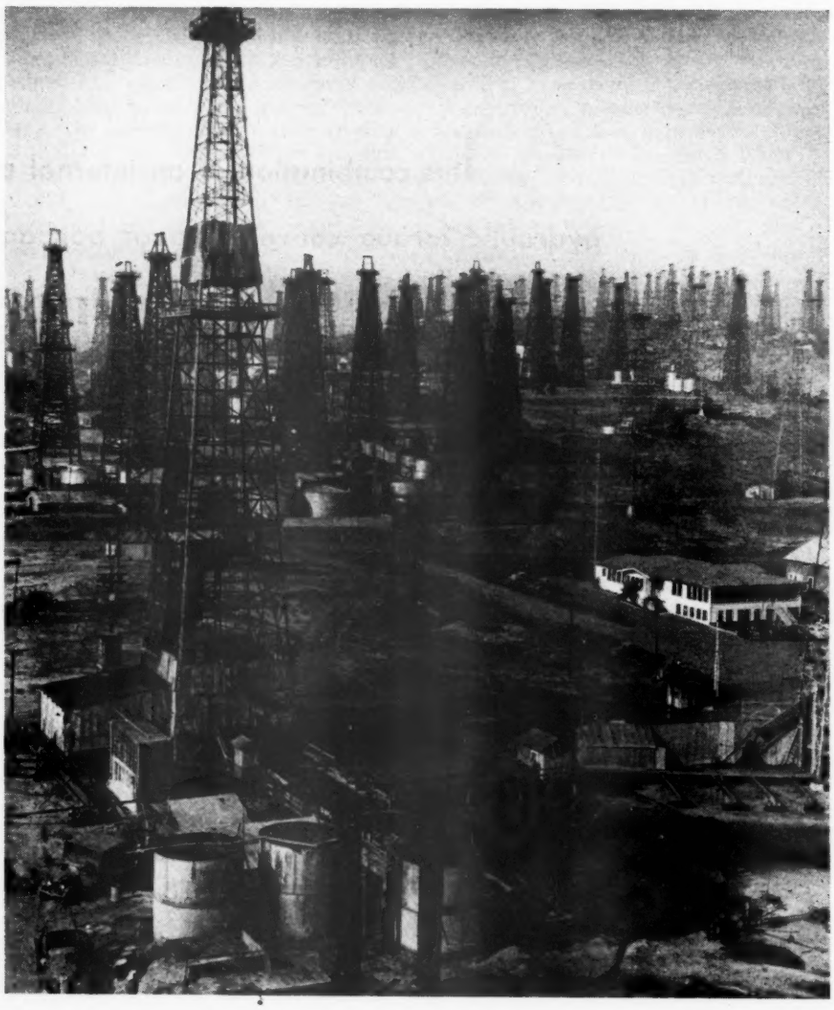
It remained for the De Soto Oil Company to discover the deepest commercial sand in the Signal Hill field. This well was drilled in 1938 and produced from 10,157 ft. It is the deepest producing zone on Signal Hill at the present time.

● **Alamitos No. 48-A.** Shell began drilling its deep test at Alamitos No. 48 location. This well ran into trouble from lost circulation between 5000 and 6000 ft. The zone could not be sealed off by conventional methods even by cementing. A difficult fishing job resulted, due to the lost circulation, and the hole was abandoned and the derrick skidded to its present location.

Alamitos No. 48-A was spudded in on October 21, 1944, and drilling was completed at a depth of 14,950 ft. 414 days later. Lost circulation was the main trouble in the drilling of Alamitos No. 48-A

Analysis of drilling time, Alamitos No. 48-A

Operation	Days	Per cent
On bottom drilling and coring	153	37
Making round trips	127	30.6
Fishing	41	10
Setting casing and cementing	22	5.3
Repairs	14	3.4
Changing drill pipe	10	2.4
Lost circulation	8	1.9
Taking logs	6	1.5
Miscellaneous	33	7.9
	414 days	



Overall view of Alamitos No. 48-A drilled to 14,950 ft. within short distance of Shell Oil Company Incorporated's main camp at Long Beach, Calif.

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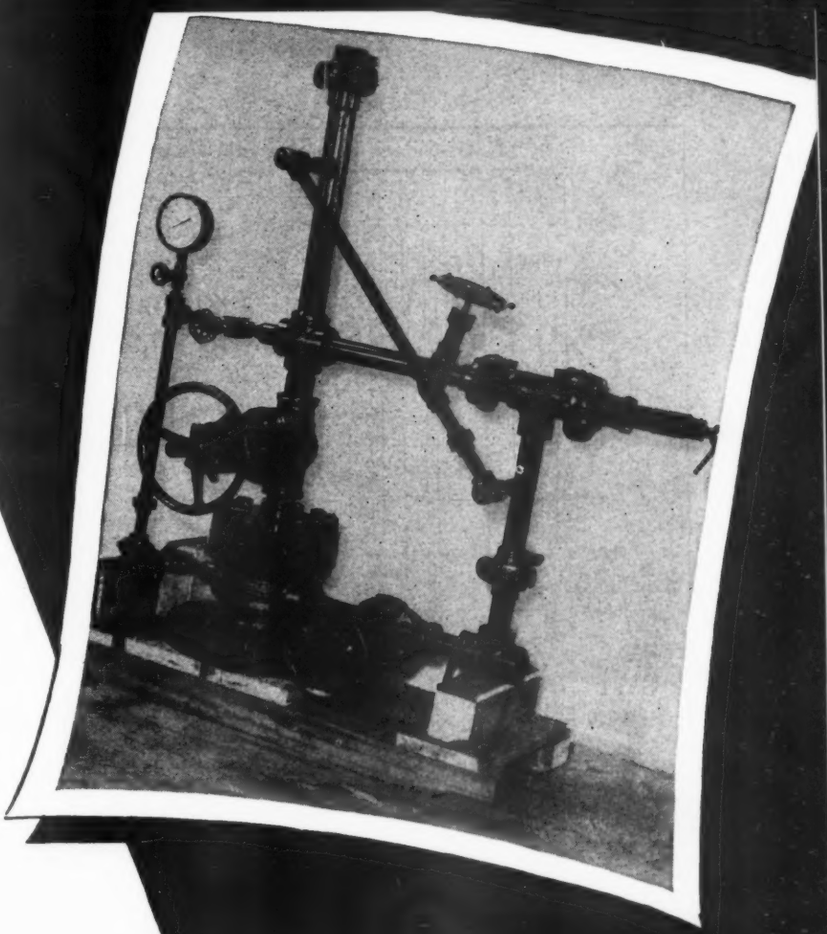

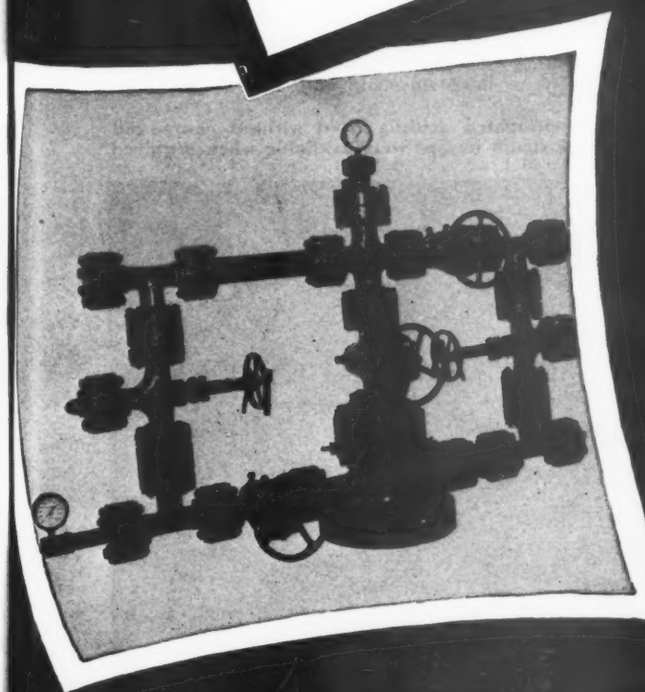

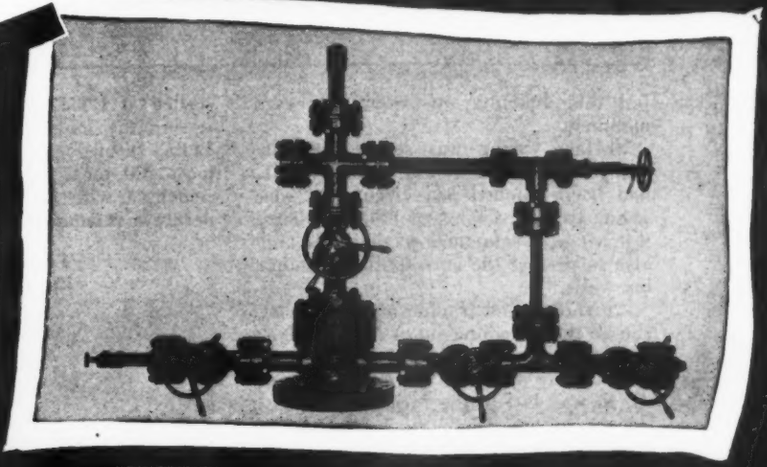

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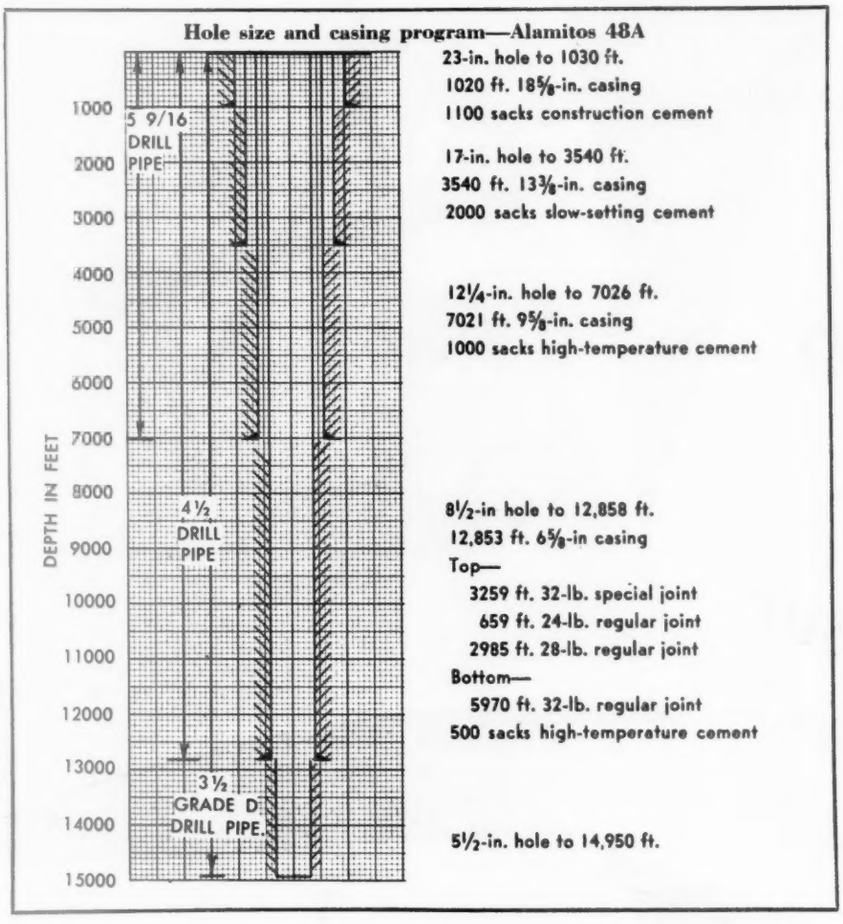


but this difficulty was eventually surmounted.

Surface casing was set at 1002 ft. without difficulty. By the time 3540 ft. had been reached lost circulation was giving trouble. Casing of 13⅜ in. diam., was set as a safeguard to this hole and also to protect the surrounding producing wells.

At 5778 ft. the troublesome zone that caused the abandonment of Alamitos No. 48 had been encountered. Water base mud having a weight of but 74 lb. per cu. ft. was lost to the formation. Fibertex was pumped into the hole and the mud was treated to prevent water loss with but little success. Two hundred sacks of cement with 4 per cent aquagel were pumped into the formation by a squeeze cement job. About half of this was pumped away and it was possible to continue drilling to 7026 ft. where 9⅝-in. casing was set.

Drilling proceeded with 8½-in. hole to 12,858 ft. The water base mud being used between 7000 and 12,000 ft. averaged approximately 79 lb. per cu. ft. At 12,413 ft. Shell began to add a special treated oil to the clay and water base mud to reduce water loss, etc. Oil was added until the drilling fluid consisted of approximately 29 per cent emulsified oil. With this mud, drilling proceeded to 12,858 ft. At that depth an appreciable amount of mud per day was being lost to the formation and it was again necessary to set casing.

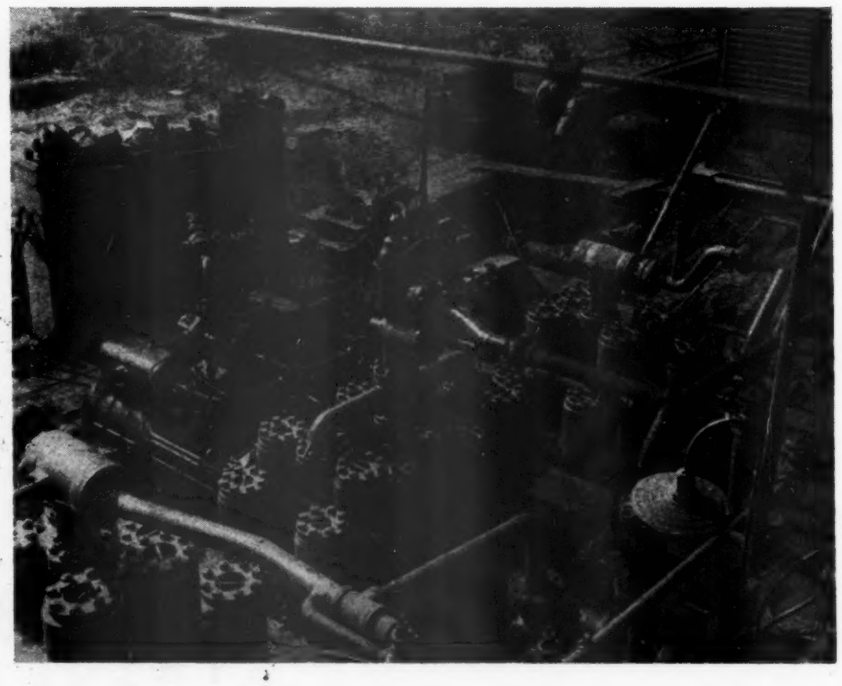
A new 1¼-in. drilling line was installed at 12,842 ft. in preparation for setting the long string of casing. The 12,853 ft. of 6⅝-in. casing, weighing almost 200 tons, was set in 14 hr. and cemented with 500 sacks of high temperature cement. At this point the 4½-in. drill pipe was laid down and drilling was resumed with 3½-in. grade "D" drill pipe. A 5½-in. hole was drilled to bottom.

● **Drilling mud features.** Mud circulating pressures with the 4½-in. drill pipe were approximately 1200 lb. per sq. in. Immediately after the 3½-in. pipe was placed in service this pressure jumped to 2100 lb. In drilling ahead, however, the mud pressure evened off at about 1800 lb. per sq. in. at 12,900 ft. and gradually increased to 2000 lb. at 14,950 ft. A triplex steam pump with 6½-in. liners was able to supply sufficient volume and maintain the desired pressure without the need of compounding the slush pumps.

Water base mud was used after the 6⅝-in. casing had been set to protect the hole. At 13,802 ft. treated oil was again added to the mud and it had several beneficial effects. One of the important advantages was the lubrication of the drill pipe, which had to be run without rubber protectors. The inside diameter of the 6⅝-in. casing was only 5¾ in. and the maximum outside diameter of the drill pipe was 4¾ in. This, of course, made it impossible to protect the casing from abrasion unless a lubricant was added to the mud. It is also asserted that the treated oil added to the fluid reduces water loss and produces a thin filter cake.

● **Surface treatment of mud.** A long ditch was employed to allow the fine sand to settle out of the mud after it passed over the shakers. Two steam turbine driven shaker screens were used to remove the cuttings. The mud went from the ditch into a series of flooded suction mud tanks if it was in good condition. When the mud became gas cut it was pumped into 500-bbl. steel tanks and allowed to stand until it had lost its gas

Triplex steam pump circulated drilling fluid without compounding although two other steam pumps were available when required.



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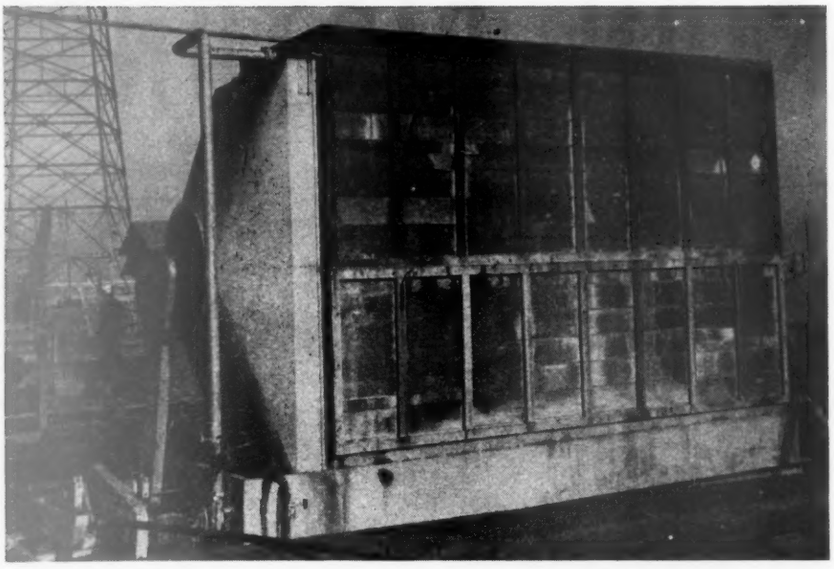


Special Shell built and developed mud cooler helped to condition mud when bottom hole temperature reached 350°F.

content. The degassing was speeded up by agitating the mud with jets from the mud guns.

Mud temperature was controlled by the use of a special mud cooler developed by Shell engineers. This unit consists of a series of coils of tubing through which the mud is pumped after it has passed over the shakers. Water is sprayed onto the tubing and a forced draft of air is maintained by use of a 48-in. diam. 8-blade fan. At a depth of 11,800 ft. on Alamitos No. 48-A the mud temperature was 122°F. before passing through the mud cooler and 109°F. after cooling. Reducing the temperature of the mud aids in keeping the mud in good condition, reduces its viscosity and water loss, and tends to result in a mud with a thin filter cake. Mud cooling is essential with a bottom-hole temperature of more than 350°F. as recorded on Alamitos No. 48-A.

Control of porous formations and loss of circulation was the main mud problem. Very little high pressure gas was encountered and the mud weight seldom went above 82 lb. per cu. ft. One high pressure gas zone was encountered below the bottom of the 6⅝-in. casing but it presented no difficulty. Formations at the extreme bottom of the hole gave some trouble from sluffing into the hole while working to recover the final fish.

● **Drill pipe parts at 14,875 ft.** What is reported as being the deepest inside cut ever successfully made was necessary as a result of a lost string of drill pipe. The 3½-in. grade "D" drill pipe parted at the surface in a tool joint when going into the hole after drilling to 14,875 ft. All but 2375 ft. of pipe was in the hole when it parted and a long fishing job resulted. A 5-in. 4-blade mill was run, after taking an impression of the fish. One foot was milled off the top of the pipe. An impression was taken after milling and it revealed a smooth cut on the 3½-in. pipe. A 5½-in. socket with bumper sub and pack off was then run and it took hold of the fish at 2391 ft. Circulation was broken with 4200-lb. pressure and a 120-ton strain was placed on the pipe. The fish would not move. Several leaks resulted at these high pressures and they were repaired. A high pressure cementing unit was then brought into service and it built up to 5100 lb. per sq. in. fluid pressure. Circulation seemed to be restored and the pressure gradually dropped until the triplex pump could continue the circulation.

After circulating 560 bbl. of fluid it was apparent that circulation was not being obtained from the bottom of the hole. Lamp black was added to the fluid as a tracer. Calculations of the amount of fluid pumped before the lamp black returned to the surface indicated a leak in the drill pipe upon which the socket was mounted. In pulling the pipe it was found that a box washed out 806 ft. from the surface and within 30 ft. of the location calculated with the aid of the lamp black tracer. The bad sections of pipe were removed and the socket run again. This time over 5000 lb. per sq. in. pressure was held for 5 hr. without breaking circulation.

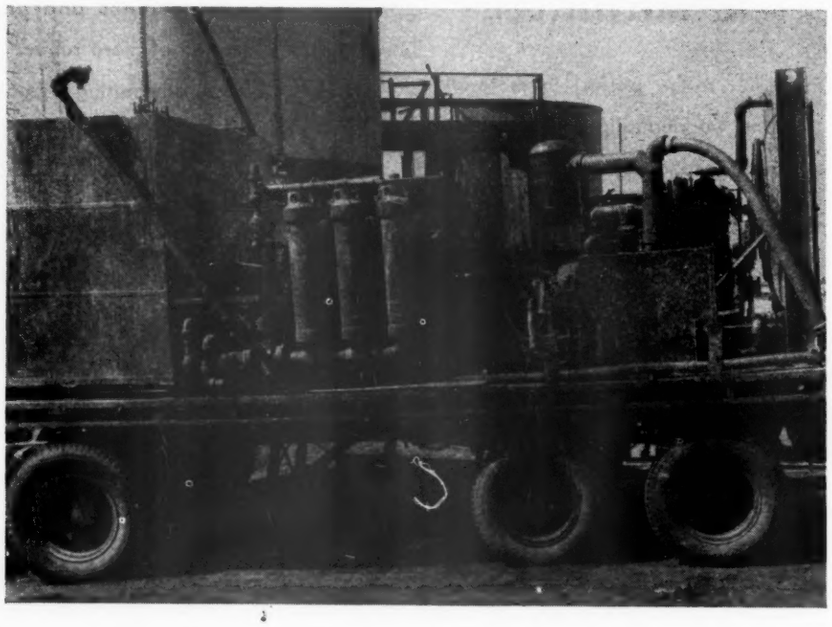
● **Inside cutting at 14,584 ft.** A 5½-in. full-hole releasing socket was run and secured on top of the fish. An inside cutter was then run on 1¼-in. drill pipe to 14,755 ft., where strain measurements indicated the pipe was frozen. Attempted cuts were made at 14,755 ft., where the cutter stuck, and at 14,730 ft., where the cutter was rotated for 5 hr. before it stopped. The cutter was then pulled up to 14,570 ft. and the control valve rams were closed on the 1¼-in. pipe. A pressure of 3000 lb. per sq. in. was applied between the 1¼-in. drill pipe and the inside of the 3½-in. drill pipe by pumping into the pipe to which the releasing socket was attached.

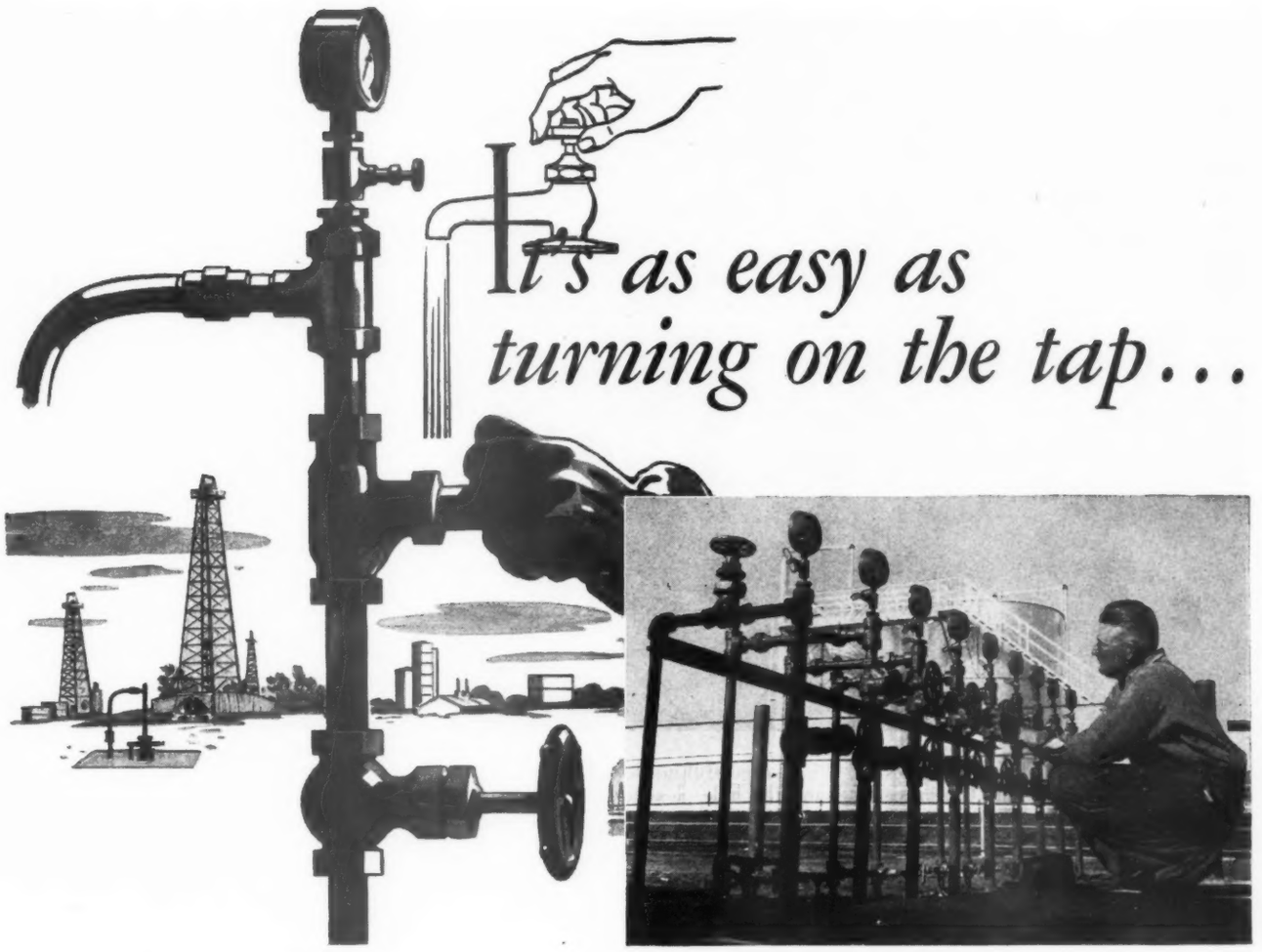
The 1¼-in. drill pipe was then pulled and laid down while a test was made on the 3½-in. drill pipe. A 3000-lb. pressure dropped to 1500 lb. in 2 min., indicating a leak. The leak was found in the packer at the top of the fish. A socket with dual packer was then run and it held a pressure of 3000 lb. per sq. in. without any circulation.

A 2¼-in. inside cutter was again run on 1¼-in. drill pipe being careful to circulate every 1000 ft. as the cutter was run into the hole. This continued until 14,000 ft. was reached where it was impossible to circulate. The cutter was run to 14,601 ft. even without circulation and it rotated at the depth for 8½ hr.

The cutter was pulled and pressure of 4200 lb. per sq. in. was applied with high pressure cementing equipment. A strain was held on the pipe constantly

High pressure cementing equipment used on Alamitos No. 48-A required to maintain 5000-lb. pressure in fishing operations.





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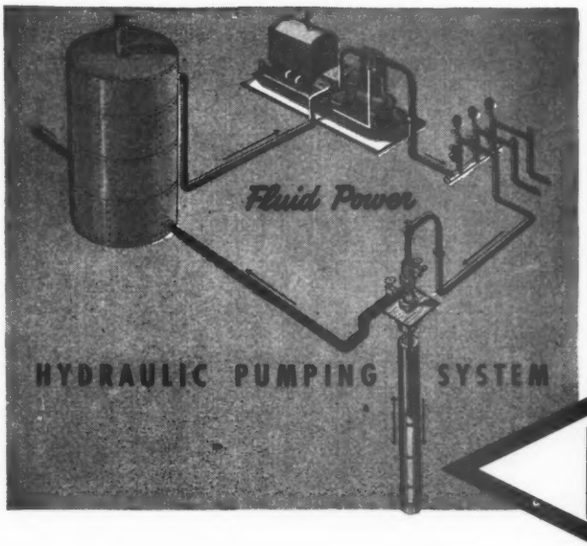

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Air-operated drill pipe slips controlled by valve at driller's position were used.

and the fish was gradually worked loose. It was pulled up inside the 6⅝-in. casing before it was possible to break circulation. The mud was reconditioned as soon as it was possible to circulate and a total of 14,591 ft. of 3½-in. drill pipe was recovered in the fish.

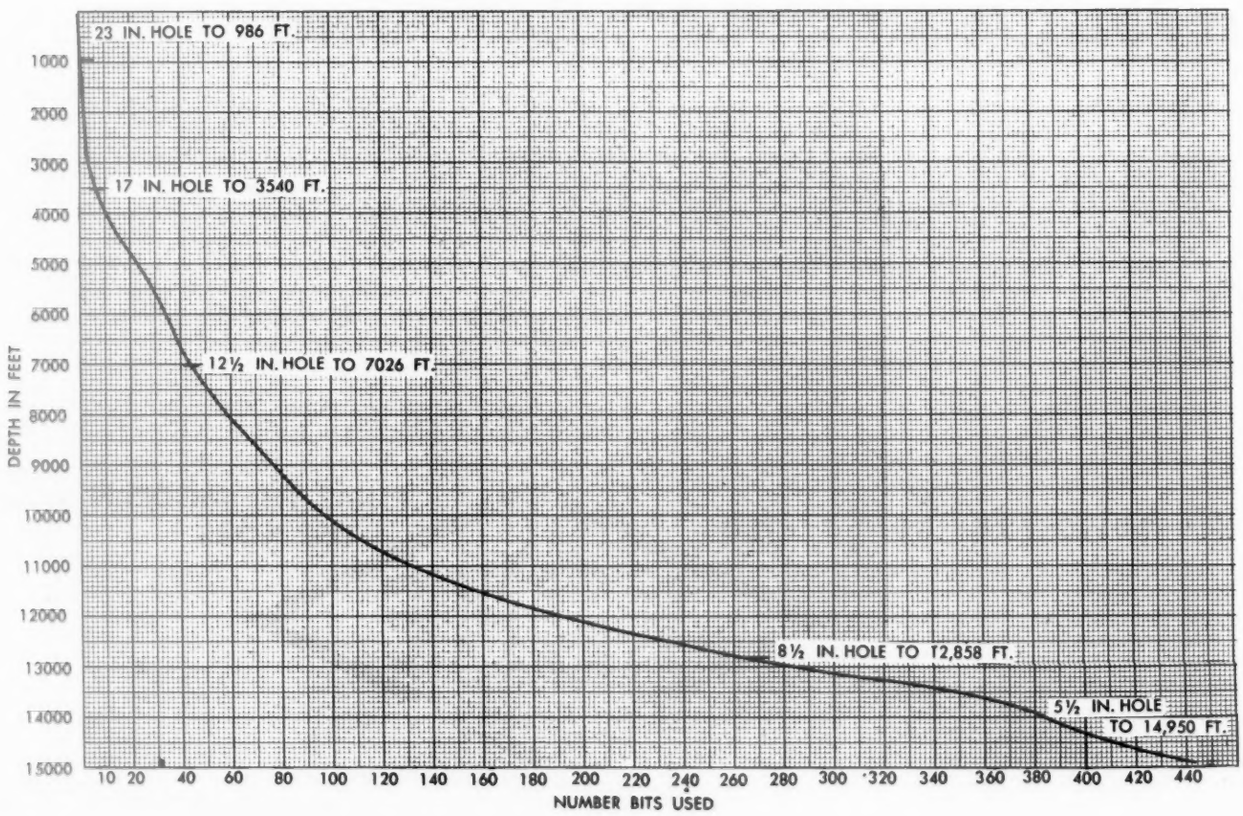
A successful inside cut had been made and the hole cleaned out to a depth of 14,584 ft.

● **Fishing for drill collars.** The 3½-in. drill pipe removed from the hole was taken into the Shell shop and a large portion of it straightened, reconditioned, and returned to Alamitos No. 48-A for further work. This shows how critical drill pipe was at the time this well was being drilled. A 5½-in. bit was run in the hole and bridges were cleaned out between 13,165-210 ft., 13,871-940 ft., and 14,088-129 ft., and the hole was cleaned out and reamed from 14,465 ft. to the top of the permanent fish at 14,584 ft. Mud was reconditioned and circulated to restore the hole to the best possible condition. Several trips were required before it was possible to enter the hole and pull out of the hole without hitting obstructions.

A 5¼-in. releasing socket with rotary jars was then run on the bottom of 3 drill collars and the drill pipe in an effort to recover the rest of the fish. The socket failed to hold on the first trip but it held later and pressures up to 2500 lb. were maintained with the triplex steam pump and then 2800 lb. with the cementing equipment. This pressure gradually declined and jarring continued but the fish remained solid. The socket was pulled and it was found that the packer rubbers were in bad condition.

A 5¼-in. overshot was then run on the 3½-in. drill pipe and dual packers were included in the assembly. This took hold of the fish and packed off. The cementing equipment was again used in an effort to break circulation and it built up and held 5000 lb. per sq. in. for 20 min. without pressure drop or indication of

Number of bits used in drilling Alamitos 48A



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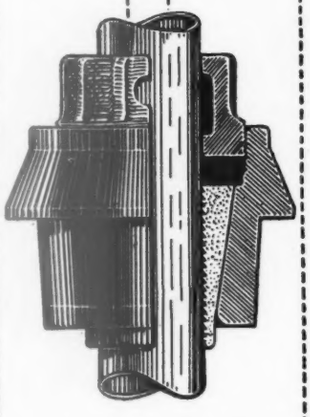

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restored circulation. At this time it was concluded that it would not be practical to recover the remaining 391 ft. of drill collars and drill pipe and the fish was left in the hole.

● **Whipstock set at 14,584 ft.** A 5-in. combination whipstock with casing bowl was then lowered on the drill pipe. This whipstock was set on the fish at a depth of 14,584 ft. with the special casing slips fastened to the fish. A 10-ft. taped stock was used to guide the bit. A 5-in. pilot bit was then run on a 9-ft. drill collar and the drill successfully passed the whipstock and continued to drill to 14,586 ft. The next bit carried the hole to 14,601 ft. and from there to 14,950 ft. drilling improved. Some of the easiest drilling was below 14,000 ft.

The well was completed by setting 4½-in. liner from 12,783 to 14,947 ft. with 100 mesh perforations from 14,595 to 14,947 ft.

● **Drilling equipment.** The drilling equipment used was termed "extra heavy steam drilling equipment" and it is in general similar to that used on many of the deeper fields in the San Joaquin Valley and at Ventura. There were some interesting pieces of equipment used that deserve special mention as they are not in general use in the industry. Some of these were on their initial well and they were developed on this hole. The mention of this equipment does not indicate that all the equipment mentioned has the approval of the Shell Oil Company, Inc., as standard equipment.

The driller had more control of his operations on this well than on most. The drawworks were equipped with 2 friction catheads, both controlled from the driller's position. With these catheads the driller was able to make and break joints and control the spinning of the pipe. Air-operated drill pipe slips also were controlled by valves at the driller's position. With this control he was able to determine when the slips should be set. Air-operated slips are a big advantage to the roughnecks, for they remove much of the heavy work.

An electrical weight indicator was used in drilling Alamitos No. 48-A. This is one of the units developed and tested on this well. The electric weight indicator measures the strain in the hook and thus records the actual hook load. By a multiple calibration it is possible to obtain the hook load on one set of calibrations and by throwing a switch obtain the weight of the bit on bottom.

A double hydromatic brake was mounted on the drawworks. This brake was installed by Shell mechanics in the field at Long Beach when a single brake was retired after the well had been drilled to a considerable depth. The brake water was cooled by circulating it through the mud cooling system when going into the hole. This is another of the advantages of the Shell developed mud cooling system.

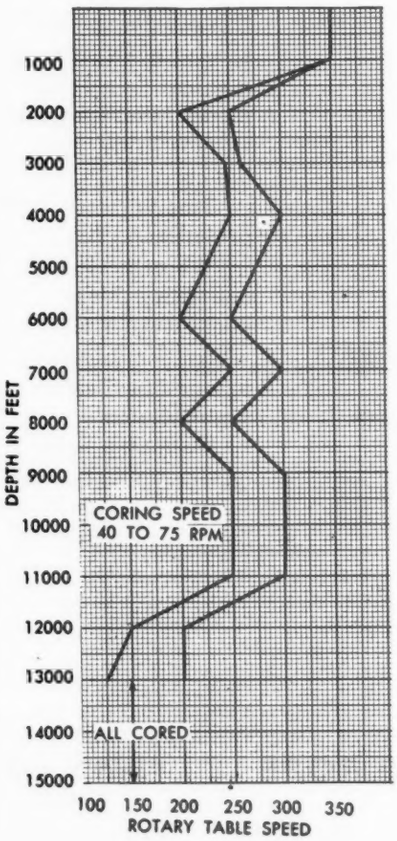
Three heavy duty steam pumps were installed at the location and on occasions it was necessary to compound them. Most of the mud circulation was done with the triplex pump equipped with 6½-in. liners.

Two steam engines were used in drilling. A 14 by 14 duplex steam engine was used to power the drawworks and it was equipped with a steam kicker on the reversing lever. A 12 by 12 engine was mounted under the derrick floor and it drove the rotary table through a subfloor drive. This second engine allowed the drawworks chain to remain idle while rotating. An independent sand reel was used and it had its own steam engine. The reel was capable of spooling more than 15,000 ft. of ⅝-in. sand line. This sand reel was used in taking numerous wire line core samples and single shot surveys. Five unitized 150-hp. 350 lb. super-heated boilers provided steam for the drilling operations.

A 178 ft. steel derrick was used and the drill pipe was pulled in 120-ft. sections. The average time for making a round trip at beyond 14,000 ft. was 8 hr. There are several cases where the round trip was made in 7 hr. when drilling below 14,500 ft. The tall derrick, long stands of pipe, and great amount of cased hole all helped reduce the round trip time.

● **Conclusion.** Drilling this well with drill pipe then available was a real accomplishment and the Shell drilling department and engineers took advantage of many innovations and new devices. The successful use of inside cutters and whipstocks set on casing bowl slips at 14,584 ft. will give other operators confidence to proceed with difficult deep fishing jobs. ★★★

Rotary table speeds—Alamitos 48A



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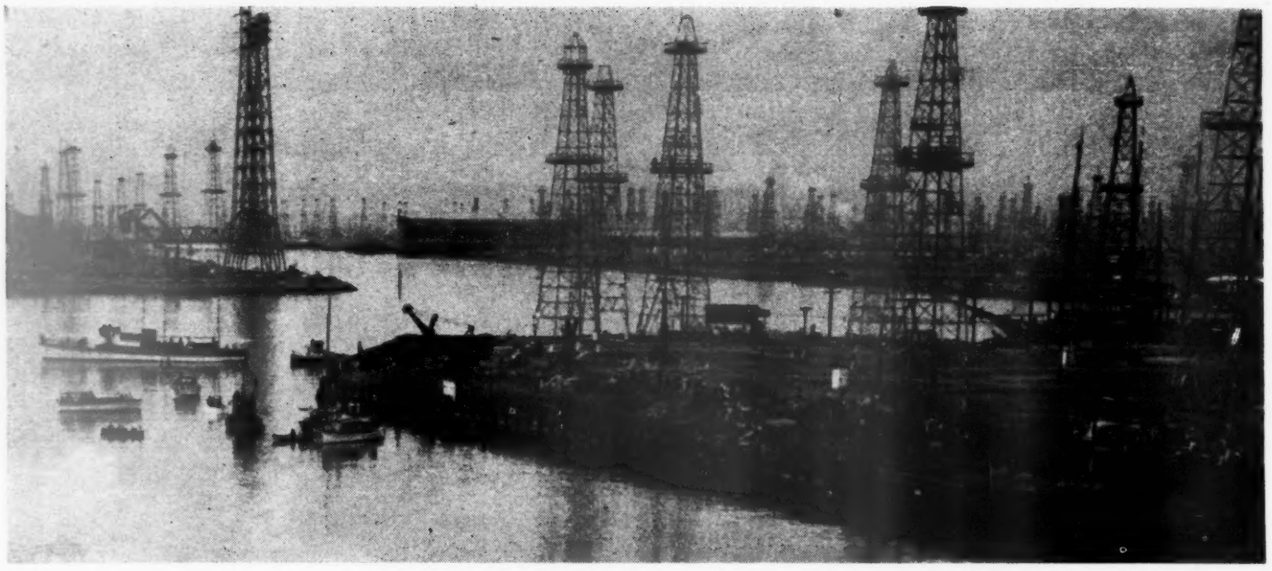


Derricks in Long Beach Harbor, California

IMPROVED TECHNIQUES AND METHODS IN CONTROLLED DIRECTIONAL DRILLING

By **GORDON JACKSON**

Chief Engineer, Eastman Oil Well Survey Company

THE positive control of the direction taken by an oil well bore during drilling —accomplished by techniques and methods first applied on an extensive scale during the early 1930's—became a vitally important factor in greatly augmenting the supply of oil and petroleum products for military purposes during recent war years.

EXCLUSIVE

The successful results achieved in the initial use of these techniques and new combinations of methods in oil fields of the United States were paralleled by corresponding successes in all type of strata and under the many and varied conditions existing in oil fields throughout the world. Oil for war, which would have been inaccessible through the use of previous drilling methods, was brought out in tremendous quantities through directionally drilled wells in locations ranging from the Norman Wells at the Arctic Circle to the desert sands of Egypt.

In addition to reaching new oil sources, the protection was achieved through the use of directional drilling in the cases where a cratered or burning well threatened large oil fields and could not be brought under control except by means of a relief well accurately directed from an adjacent site to intersect and cut off the wild well.

The directional drill is used to find oil in places difficult to reach and to stop fires by relief wells.

During the war years 5 or more outstanding control jobs of this type were drilled in the Mid-Continent and Gulf Coast areas. Perhaps the most interesting case was the West Lake Verret field in Louisiana where the entire area of the swampland field became covered with water boils and geysers due to gas migration from a damaged well. Control heads at several wells became submerged, many wells blew out, and the extreme agitation of the water created operational hazards. A directional relief well was drilled to 11,510 ft. and pumping operations successfully shut off the gas migration and saved the production of the entire field.

In California, directional drilling was carried on under difficult wartime conditions, hundreds of slant holes being drilled under large naval bases and graving docks at Long Beach. These drilling operations were achieved without interrupting the repairs to damaged battleships, and under the severe handicaps of total blackout conditions and wartime secrecy restrictions. Many directional wells were drilled in the very midst of the shipyards and associated construction activities.

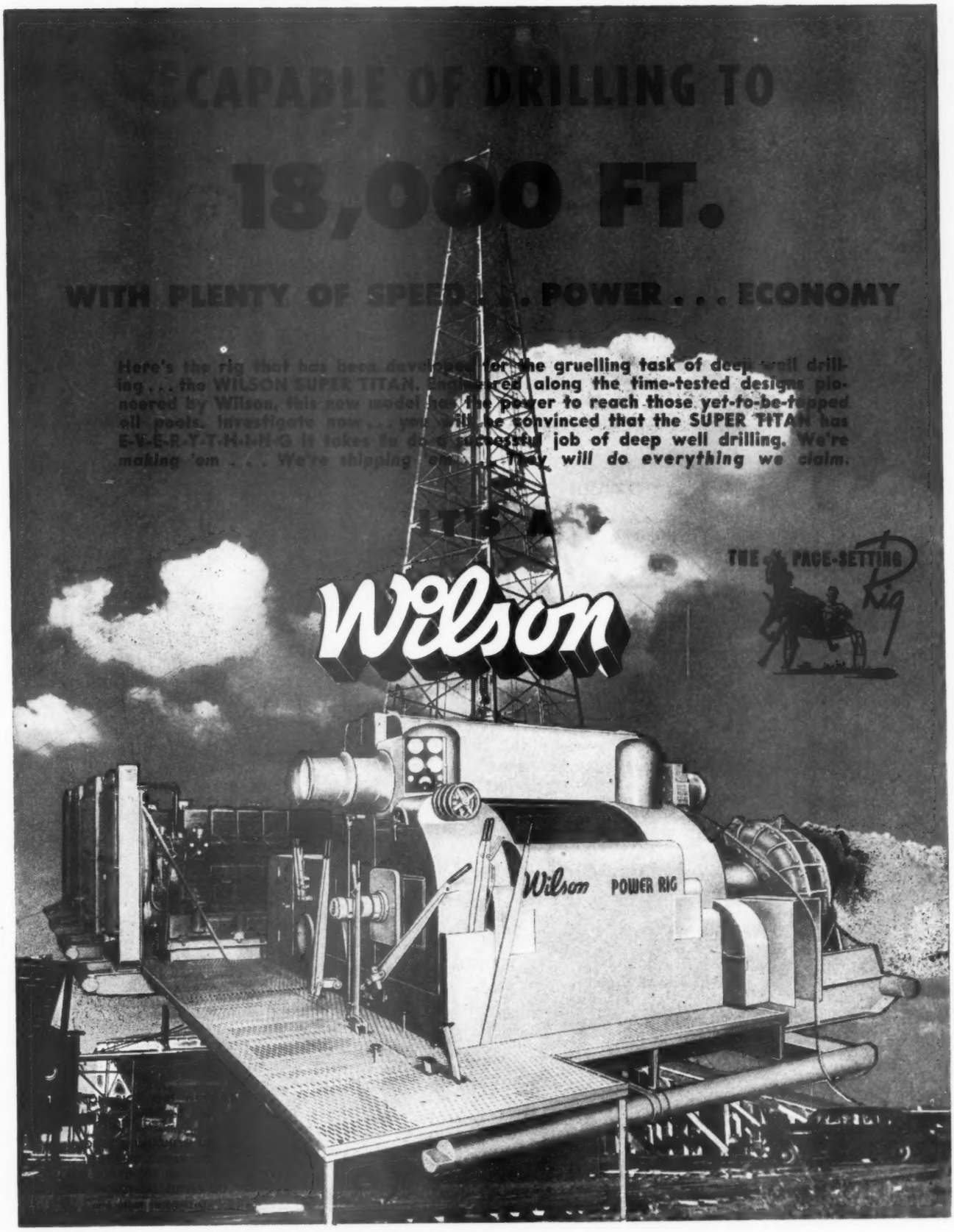
Huntington Beach produced a tremendous amount of oil from offshore tideland pools, this oil being recovered only because the techniques of directional drilling made it possible to slant wells seaward from the shore.

Production figures of directional wells in this field during the years 1941-44, inclusive, are as follows.

1941	4,329,350 bbl.
1942	4,500,870 bbl.
1943	5,389,934 bbl.
1944	9,026,794 bbl.
Total	23,246,948 bbl.

Similar examples of vast quantities of oil made available to the war effort through directional drilling could be cited in the case of many other fields throughout the world.

● **Directional drilling engineering.** As is now generally known, controlled directional drilling is the intentional deviation of a bore hole toward a predetermined subsurface location. Two principal factors enter into the procedure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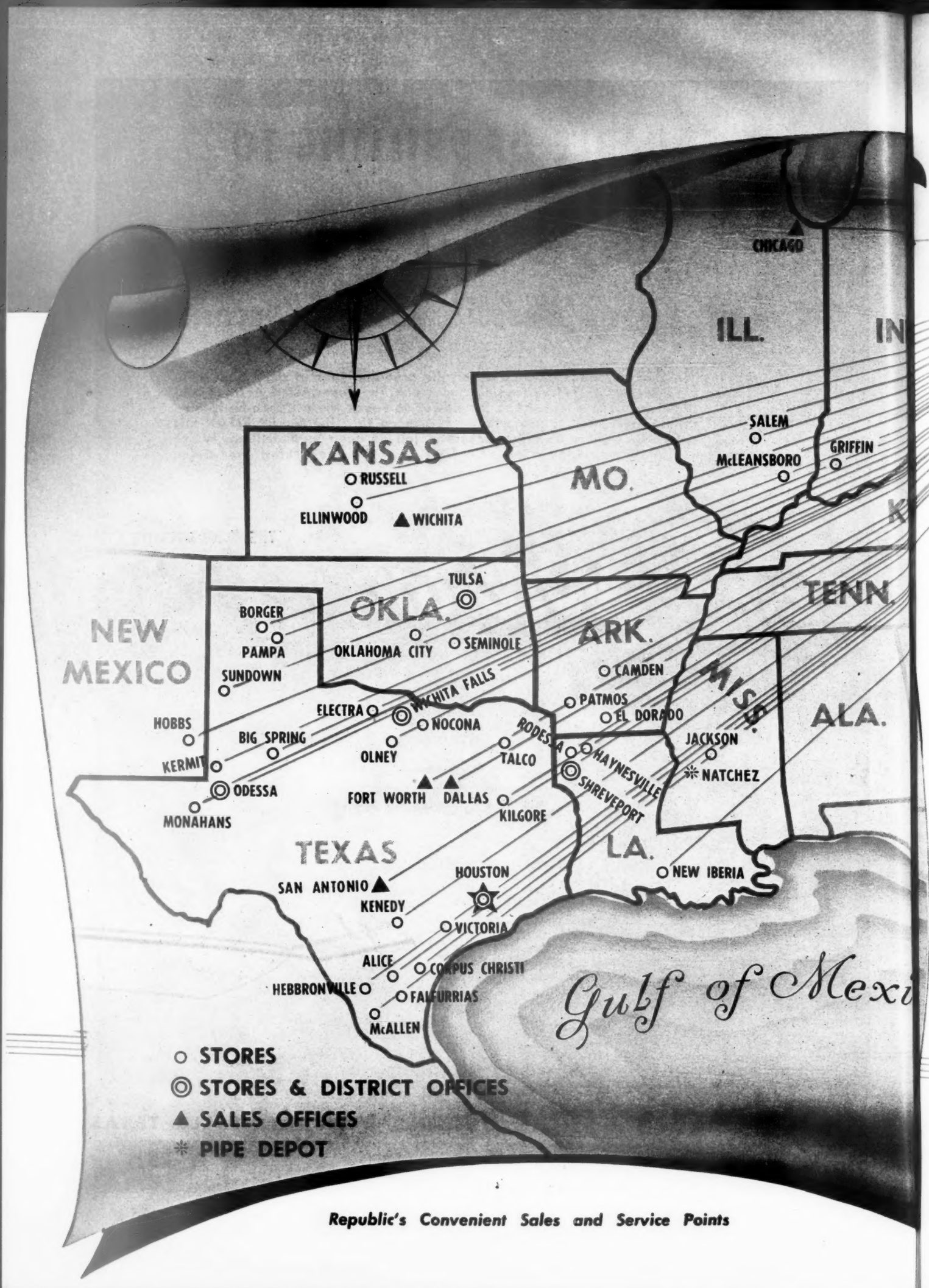

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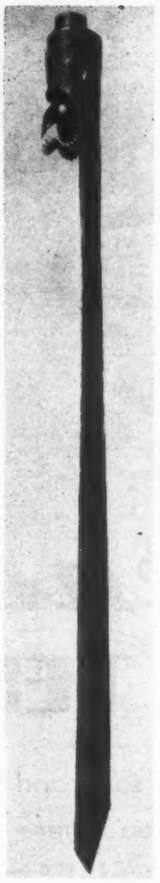
in order that the objective may be reached speedily and with certainty: (1) The actual control of the course of the drilling bits through the use of appropriate tools, and (2) the accurate determination and recording of the course of the bore hole at all points through the use of specially designed surveying instruments.

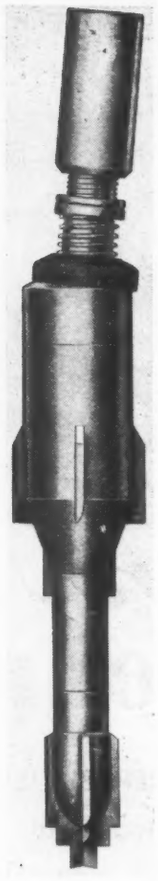
The many successful applications of controlled directional drilling in increasing wartime production of oil indicate the important future uses of these methods in the peacetime procuring of further production from existing fields and in the discovery and exploration of new oil sands. Among these applications of controlled directional drilling may be mentioned (1) deflecting from accessible locations to inaccessible locations, (2) deflecting around and under salt dome overhangs that are difficult to drill through, (3) deflecting out of salt dome cores to adjacent oil sands, (4) deflecting relief wells into wild, burning or cratered wells to bring them under control, (5) deflecting a hole from an unproductive to a productive portion of a lease, (6) deflecting an old depleted well to a new location in producing territory, (7) deflecting across faults or out of fault zones into a productive area, (8) deflecting a hole back into the lease after it has deviated over a lease line, (9) deflecting a plurality of wells from one location, or from a physically restricted area such as an island, (10) deflecting a series of holes for sub-surface geological exploration, (11) deflecting a hole so a sand can be cored after it was first drilled through without coring, (12) sidetracking fish or obstructions in the well, (13) deflecting a well back into a hole that has caved and was lost, and (14) deflecting off at an angle in oil formations to give greater penetration.

The vast amount of experience obtained during wartime years has enabled the engineer in charge of directional drilling operations to do a much better and more efficient job, and has been the foundation for the current major trend toward the use of tools, methods, and drilling techniques that will increase drilling speeds and at the same time lower costs in forthcoming peacetime operations.

Speed and accuracy of directional drilling has increased at a much greater rate in recent years than it did in the years prior to the war. Its place in the field of oil well drilling is of such importance that it is now common practice for many companies to include the factor of possible directional drilling work when they are laying out their drilling programs. Among the more notable recent achievements in directional drilling practice has been the high drift angle that engineers have been able to maintain in directionally drilled holes. Angles from 60 to 80 deg. from the vertical are now easily held for many thousands of feet of drilled hole. An outstanding example is found in a California well that was drifted more than 5000 ft. horizontally with a measured depth of slightly over 7000 ft.



Full-gage whipstock



Self-orienting deflecting tool

A brief summary of some of the tools and methods used is given in the following paragraphs.

● **Full gage directional drilling tools.** The newest and most advanced types of deflecting tools are those that drill a full-gage hole, or one so nearly full-gage as to make unnecessary a secondary reaming operation. By eliminating the need for the reaming of rat holes, thereby saving the accompanying round trips with special reaming bits, a considerable time saving has resulted to the operators.

The three most common types of full-gage tools now being used in directional drilling work are the full-gage whipstock, full-gage knuckle joint, and the full-gage self-orienting "Driftmaster." Although there are other full-gage tools on the drawing boards, those mentioned tools have been given enough field trials to prove their worth under actual drilling conditions.

The full-gage whipstock is one that is especially designed with a bit much larger than that used in the conventional whipstock. The bit drills a hole that is but slightly smaller than the gage of the well bore, making it practical and easy to follow this lead hole with the conventional drilling set-up and a full size bit.

The widest and most practical use of the full-gage whipstock up to the present time has been in wells bored in sizes of from 9 in. up.

The full-gage whipstock run, instead of being followed with a pilot reamer, is usually followed by a directional drilling set-up, such as a bit, a reamer, and a short drill collar. With this type of set-up it is often possible to use single shot surveying equipment, so that survey pictures can be taken immediately after the full-gage bit reaches bottom. This procedure saves the time otherwise necessary to check the direction of the hole through the use of an open-hole single shot survey instrument, and if the single shot recordings show the run to be acceptable, the operator is then in a position to drill ahead without pulling out to change tools.

Besides the vast saving in time, the full-gage whipstock gives the operator at least two definite advantages. The large size bit is of decided value in sidetracking difficult plug jobs. Furthermore, the high rate of drilling speed and the fact that rapid progress is made results in much better mechanical condition of the hole and unquestionably has avoided the need for many expensive fishing jobs.

● **Full-gage knuckle joint.** The full-gage knuckle joint was developed before the war and has since had fairly extensive field trials. This tool is extremely safe to run, very rapid in its operation, and gives quite accurate results. The more recent tools are so designed as to make them usable in either soft or rocky formations. Rock type cutters are fitted to both the pilot bit and the reamer when formations are too hard for the ordinary drag type bits. In the majority of cases the full-gage knuckle is oriented by the bottom-hole orienting method.

● **Full-gage self-orienting Driftmaster.** The newest and most radical design of a full-gage tool is the Driftmaster, which has promising possibilities. This tool is a self-orienting type full-gage knuckle joint. The orientation is accomplished by the use of a mechanism actuated by gravity and contained within the body of the deflection tool. In use, a small amount of weight is applied to the pilot bit, thereby releasing the gravitational element and automatically positioning the tool in relation to the direction of the bore hole. It is then an easy matter to pick up the tool and rotate the drill pipe any specified amount so as to point the bit in the desired direction. The drilling procedure is substantially the same as when drilling with an ordinary full-gage knuckle joint.

● **Improvements in surveying procedure.** Recent improvements in surveying procedures have been made principally in the field of more effective coordination of the use of surveying instruments and directional drilling tools and techniques. Perhaps the most notable single advance has been in the widespread acceptance of non-magnetic drill collars made of K-Monel metal. These non-magnetic drill collars enable the operator to use conventional bits and still be able to check the direction of the hole at

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regular intervals without withdrawing the drill pipe and without the use of special coring equipment.

A single shot barrel is selected of such a length as to position the single shot instrument at the point of least magnetic interference in the drill collar. Quite consistent and true directional readings have been taken with the use of the non-magnetic drill collars, in bore holes having angles up to as high as 12 deg. Even though these drill collars are quite expensive, there is every reason to believe that the saving in time, both through the increased rate of drilling and the elimination of the time necessary for taking the old type of conventional single shot recordings, will more than offset the added initial expense.

Much drilling time is being saved by the use of special bits and reamers that are constructed in such a manner that surveying instruments can be used in conjunction with them to obtain directional pictures. These bits are run on ordinary steel drill collars and in almost every respect perform as well as do the conventional bits.

● **Sidetracking.** Wartime conditions and conditions since the war, until such time as more steel and other materials are available, have brought a sizeable increase in the amount of sidetracking necessary in drilling operations. Because of the shortage of steel many operators were forced to use drill pipe for a much longer time than its condition permitted with reasonable safety. Pipe failures together with the greater loads imposed on the drilling tools inevitably brought an increase in the number of sidetracking jobs.

The many troubles encountered in sidetracking these wells made it evident to the operators that better techniques and methods were necessary if satisfactory results were to be obtained. The unusual amount of experience gained on these jobs pointed to the fact that bore holes were generally either greatly oversize, or that the cement plugs were not of sufficiently good quality to permit successful sidetracking.

The condition of over-size bore holes was successfully met by the use of hole calipers. The calipers give the necessary information so that the engineers may choose the most advantageous point at which to set the deflecting tool. If a point as near as possible to the actual gage of the well is selected, the deflection tool bit has a much better opportunity to engage solid formation. Wherever this procedure has been carried out, and where the plug was of good quality, sufficiently hard, and properly filled the hole, sidetracking efficiency has risen remarkably.

Sidetracking jobs that cause an unusual amount of trouble are frequently those in which the plug is contaminated with mud and a mud ring of considerable thickness exists around the plug. In one job after another it has been found impossible to get the plug to set hard enough to permit a successful sidetracking job. This problem has been solved by running special reaming bits that first ream and wash the well bore and then permit immediate placement of the cement. In every instance where this procedure was followed, even after failure by conventional methods, the sidetracking jobs were completed successfully, leading the engineer to believe that by combining the use of the calipers and the cementing type of reamer his chances of a successful sidetracking job will be improved.

Considerable ingenuity has been displayed when difficult sidetracking jobs were encountered. Instead of following the usual methods and approaches, the directional drilling engineer has devised effective new combinations of drilling tools to meet the particular needs of the job. By the combination of the functions of different tools he can obtain an overall advantage much greater than if he had used but a single tool or method.

For example, it is now common practice to follow a large whipstock with a smaller one; to use a spudding bit to make a seat for a whipstock; to follow a whipstock run with a knuckle-joint, and to space whipstock runs in a manner to get the greatest advantage possible.

● **Cylinder drilling.** This designation refers to drilling in which the course of the bore hole is held within previously determined limits, set by the circumference of an imaginary cylinder extending from the surface location to the desired objective of the hole. It is a drilling procedure that is widely used in California. The conditions requiring this type of drilling may be compared to the situation of the utility company gas man, who, in running his gas service pipe across a street, must direct it above and below a myriad of watermains, sewers, electrical conduits, and other obstructions to a direct run. The directional drilling engineer is called upon to use the full range of his abilities in maintaining the course of the bore hole within the limits of the imaginary cylinder that has been so plotted as to avoid conflict with the damage to neighboring wells. By the successul execution of his task, properly recorded, a valuable permanent record is obtained of the course of the hole drilled and its relationship to other wells in the area.

The easements or rights-of-way obtained prior to cylinder drilling clearly establish the course the drilling is to take and protect all parties concerned in various ways, such as through the necessity for accurate drilling, and the need of maintaining the hole in good mechanical condition.

● **Conclusion.** The trend of petroleum engineering, as in the case of any forward moving industry, is definitely toward more advanced and exact thinking and planning, taking prompt advantage of new developments, an alertness toward the possibilities of improving techniques yet in the experimental stage, and the full use of established and proved tools and equipment that will aid in advancing petroleum drilling technology.

★ ★ ★

METHOD OF LOCATING A LEAK IN CASING

HENRY EMMETT GROSS, Kingwood Oil Company

EXCLUSIVE

From time to time the problem of locating a leak in the casing arises. Recently it was necessary to find a leak in a salt water disposal well that was seeping considerable brine through the bradenhead, and the following method was effectively employed.

Fe_2O_3, red iron oxide paint pigment, commonly known as venetian red, was used to color the input water. An ordinary positive-displacement water meter was placed on the outlet of the return line at the point where the water from the brandenhead fell back into the pit as shown in the diagram.

The well was filled to the bradenhead with clear water. Then, the water in the pit was colored by addition of the venetian red. The pump was started and the amount of water injected into the well was determined by gauging the pit and metering the water returned before the returns showed any red coloration. The measurements were as follows:

	Water meter, gal.	Pit gauge, in.
Beginning	573,598	36
End	573,647	52
Difference	49	16

Computation of quantities:

Quantity A = 49 gal. = 1.17 bbl.

Quantity B = 16 in. = 5.53 bbl.

Pipe factors:

	I.D., in.	Capacity per ft., bbl.	Length, ft.
Return pipe	2.067	0.00417	125
Input pipe	2.5	0.0061	100
Inner casing	5.012	0.0245	
Annulus		0.0715	

Computation of water in pipes:

Return line: $125 \times 0.00417 = 0.52$ bbl.

Input line: $100 \times 0.0061 = 0.61$ bbl.

Explanation of method of calculating the depth of the casing leak:

All the clear water above the leak in the annulus between the inside casing and surface pipe had to be displaced by the colored water. Assuming that no upward channeling of the colored water occurred in the annulus and that the pipe factor was correct, the volume of water displaced in the annulus equaled 1.17 bl., or quantity A, plus the volume of water in the return line, or 0.52 bbl., which totaled 1.69 bbl. of clear water.

The volume of water in the return line, 0.052 bbl., was displaced from the annulus before the water meter began to register.

The calculated depth of the leak is simply this volume of clear water divided by the capacity per ft. factor:

$$\frac{1.69}{0.0715} = 23.6 \text{ ft.}$$

Analysis of test:

The volume of colored water pumped out of the pit during the test was the total of the following:

Quantity B	5.53 bbl.
Quantity A	1.17 bbl.
Total pumped	6.70 bbl.

The volume of colored water that moved on down the inner casing to replace water forced into the face of the formation was simply the total pumped less the total returned out of the bradenhead, or $6.70 - 1.69 = 5.01$ bbl. This indicates that the colored water moved downward to a depth of 204 ft. ($5.01 \div 0.0245$) during the time the volume of water in the annulus above the leak was being displaced.

Actually, the main leak was found with a light at 20 ft. showing that the determination was close enough for the particular problem, and the well was repaired by running 3-in. cement-lined tubing and a hook wall packer to 400 ft. This depth was below the cement in the annulus.

● **Summary of test method.** As stated above, the principle involved in this method of locating a leak in a casing is simply to determine the amount of water that is displaced in the annulus above the leak between the inner casing and the outer casing, or surface string. The method can be applied to wells that begin to leak between casing strings, but the position of leaks that occur elsewhere cannot be determined by this method.

Furthermore, the method is not adaptable to the location of more than one leak between casings. A series of large to small leaks distributed over a distance of 20 ft. might be located roughly within that distance, but if distributed over a distance of 100 ft., considerable difficulty would be experienced in determining the approximate location of the leaks due to dilution of the colored water.

The simplicity of this method and the fact that the well does not have to be packed off during the test are advantages but the measurements must be made very carefully and precautions taken to obtain a reasonably accurate determination of the depth of the leak.

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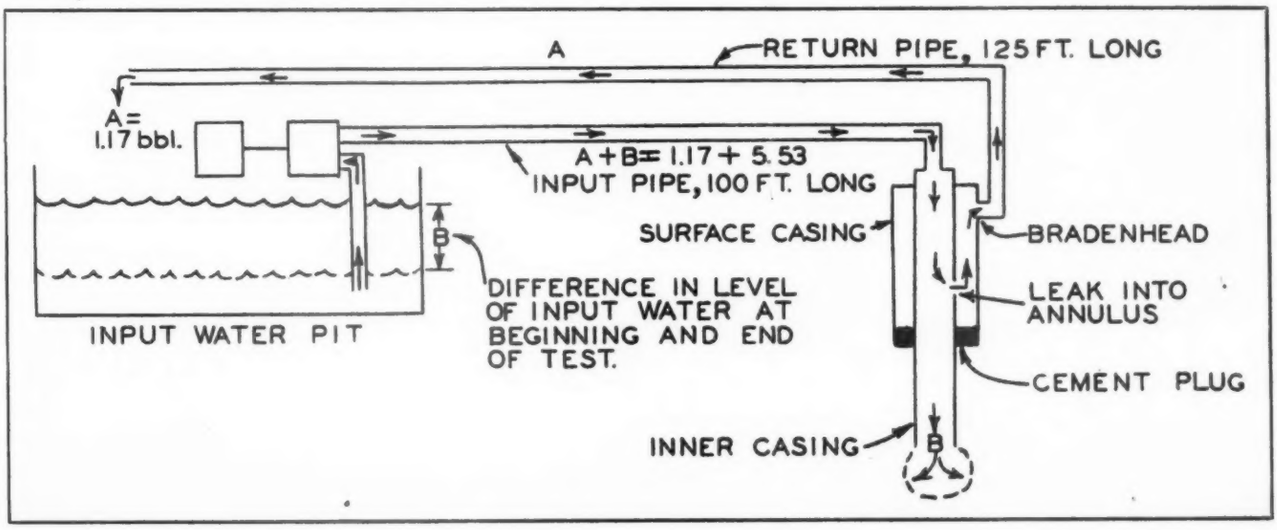

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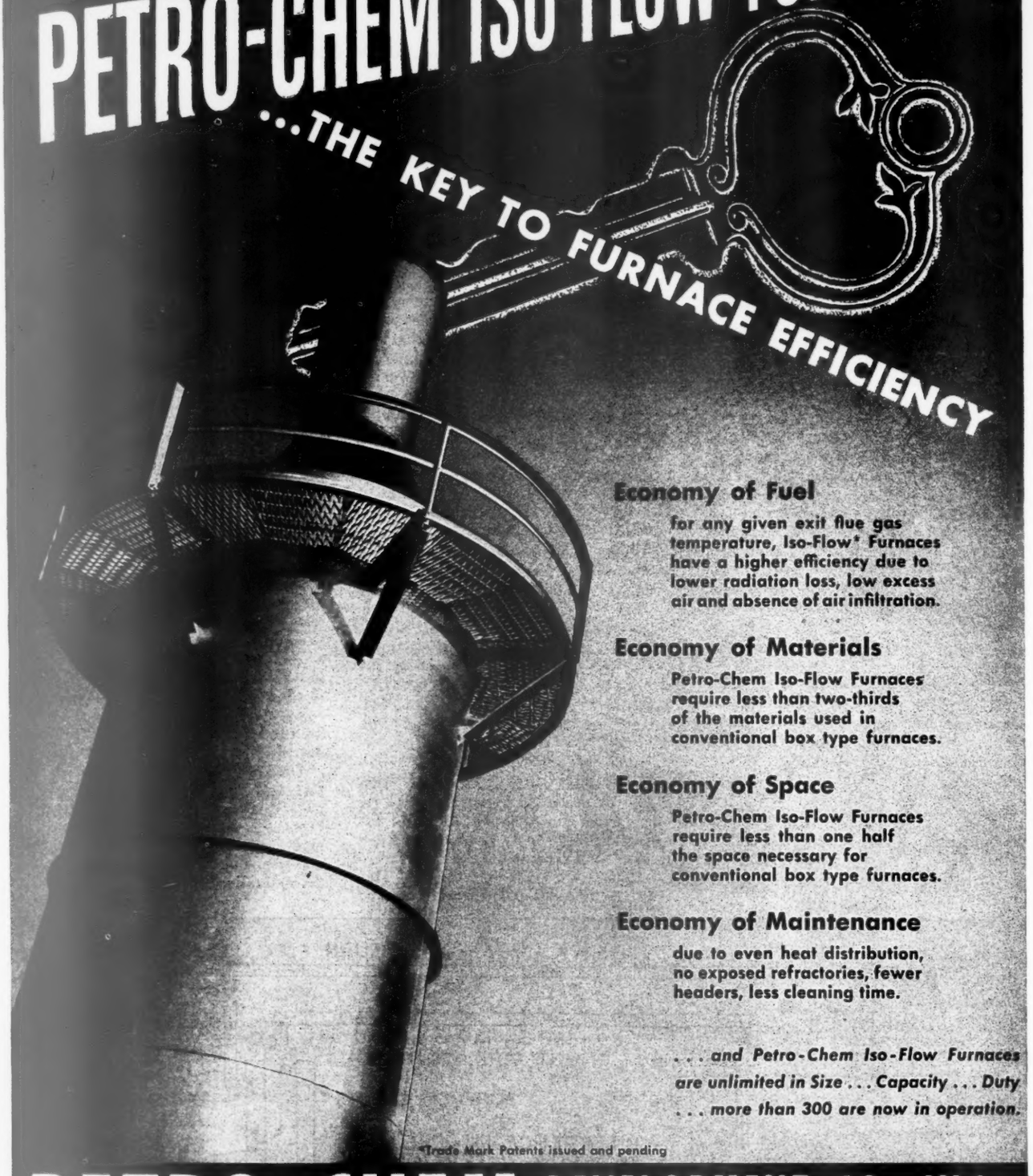

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Catalytic Reforming Process of Standard Oil Company of California

By **E. O. SAEGEBARTH,** California Research Corporation

TOLUENE requirements for the ordnance program during the war exceeded prewar supply by a factor of about ten. Prior to the war, toluene was made exclusively from by-products of coke oven operations. The large increase in toluene production was made possible by catalytic reforming. A notable share of the contributions was due to the catalytic reforming unit of Standard Oil Company of California constructed at Richmond, California, and completed in the early part of February, 1943. The process used at Richmond is different in many respects from catalytic reforming processes used elsewhere in the United States and already referred to in the literature. [1, 2, 3]

EXCLUSIVE

It is proposed to give in this article a general description of the Richmond process, to discuss some of the engineering features, and to indicate the possibilities of the catalytic reforming process in peace-time economy.

● **Process.** Catalytic reforming is a cyclic process in which a charging stock of gasoline boiling range in the presence of gas made as by-product in the process and containing from 60 to 80 per cent hydrogen, is passed over a suitable catalyst—usually a composition of alumina and molybdena—at about 1000°F. and 200 lb. per sq. in. ga. pressure. The reaction product is condensed and fractionated to obtain specific stocks. The main reaction consists of dehydrogenation of naphthenes contained in the charging stock. Depending upon the boiling range of the feed, the naphthenes consist of cyclopentane derivatives (dimethyl cyclopentane and ethylcyclopentane) and mono-alkyl or polyakyl cyclohexanes. The indicated reactions are accompanied by some cracking of non-aromatic hydrocarbons to lower boiling constituents. Finally, some alkylation occurs in the process as shown by formation of xylenes and higher aromatic hydrocarbons, in relatively low yields, from a charging stock containing methyl cyclohexane as the highest boiling naphthene.

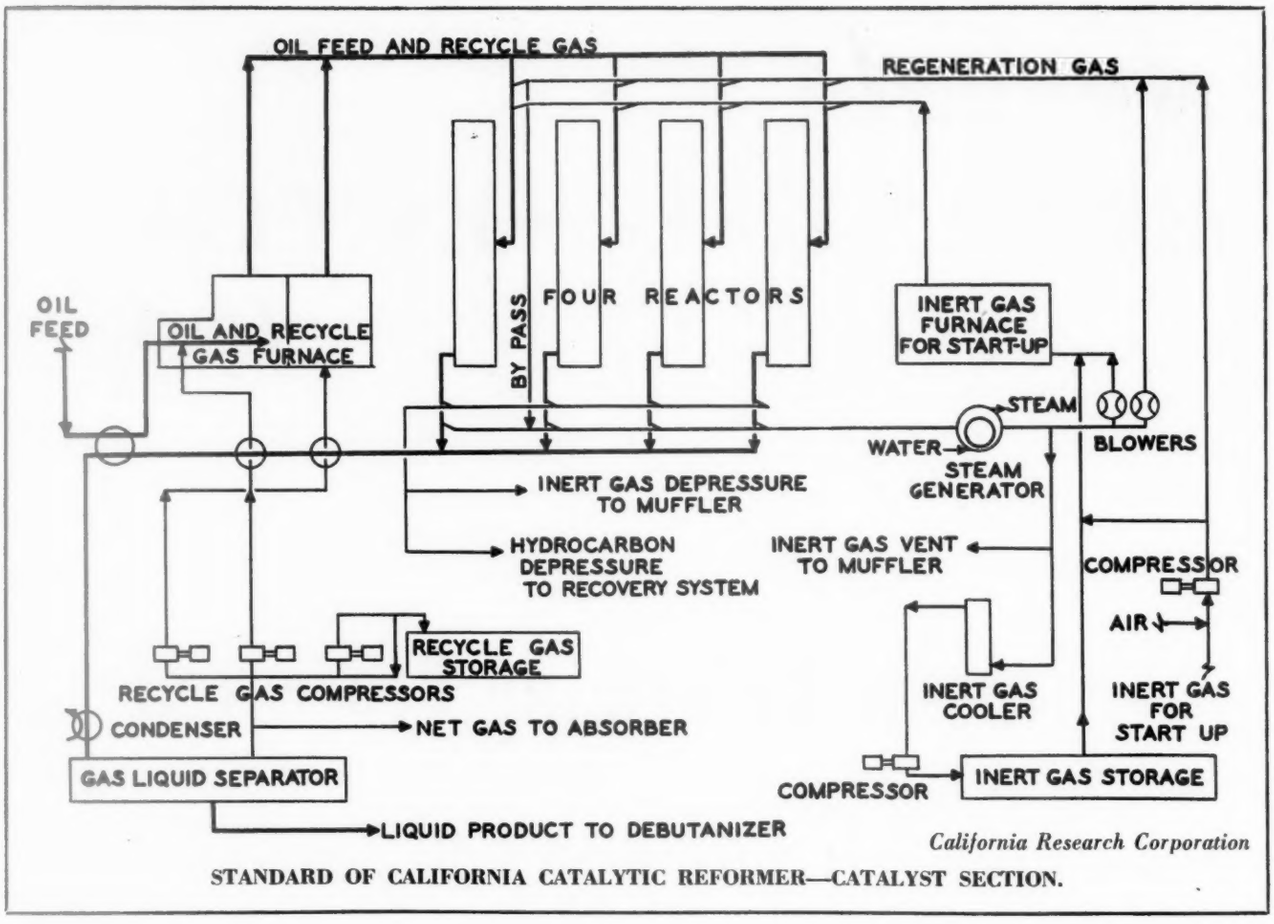
The reactions are accompanied by formation of a small amount of coke that deposits on the catalyst. This coke is removed by combustion under controlled conditions. After a certain length of time on stream, each reactor is purged of hydrocarbon vapors, repressured with inert gas made during coke burning, and the catalyst is regenerated by circulation of a mixture of this inert gas with air. Oxygen concentration of the regeneration gas is usually maintained at about 1 per cent to avoid excessive temperatures.

Process research and pilot plant development of the process employed at Richmond was carried out by the Research and Development Department of Standard Oil Company of California, now California Research Corporation. Process and engineering designs for the commercial plant were made jointly by Standard of California and California Research Corporation.

In designing the commercial unit, provisions were made for a high degree of flexibility in order to permit manufacture of products other than toluene. For this reason, installation of equipment that is specific to manufacture of pure toluene, as solvent distillation or azeotropic distillation facilities, was avoided. Instead, a new method was developed for manufacture of nitration grade toluene by which a primary product containing 85 to 90 per cent toluene was made first. This primary product was retreated in the catalyst section to convert non-aromatic components in the toluene boiling range either to aromatics or to lower boiling constituents that could be separated from toluene by conventional distillation.

Provisions were also made in the de-

[1] D. G. Smith and L. W. Moore, *The Petroleum Engineer*, Vol. 12 (No. 7), pp. 23-24, April, 1941.
[2] C. R. Wagner, *The Oil and Gas Journal*, Vol. 42 (No. 23), pp. 67-69, October 14, 1943.
[3] F. L. Hartley, *The Petroleum Engineer*, Vol. 17 (No. 3), pp. 156-166, December, 1945.



STANDARD OF CALIFORNIA CATALYTIC REFORMER—CATALYST SECTION.

sign to permit either once-through operation or recycle of product fractions that contained substantial amounts of unconverted naphthenes. For example, if the primary object was to obtain a high yield of toluene from available charging stock, a product cut boiling between benzene and toluene was recycled to the reactors where it was subjected to further conversion in conjunction with fresh feed.

The accompanying simplified flow diagram shows the catalyst section of the Richmond catalytic reformer. Feed stock preparation unit, gas recovery section, and product distillation section are of conventional design. The photographs show a general view of the unit, and of the four reactors.

Charging stock is preheated and completely vaporized by heat exchange with product from the reactors (reaction mix) in a series of exchangers. Fouling of exchangers is prevented by gas blanketing of feed tanks inasmuch as oxygen was found to be responsible for deposition of solid reaction products in the heat exchangers. Feed vapors are superheated to about 1030°F. in the oil furnace. Recycle gas from the gas-liquid separator is divided into two streams: One stream amounting to about one-fourth of the total gas is preheated in a heat exchanger and then enters the oil furnace at the center of the convection bank; the remaining recycle gas is preheated in a separate exchanger, and heated to 1030° F. in the gas furnace. Combined feed and recycle gas streams go to the reactors of which at least two are on stream. Reaction mix leaving the reactors is cooled by heat exchange with charging stock and recycle gas streams, followed by condensation in water-cooled condensers, whereupon the product is collected in the gas-liquid separator. Liquid product is pumped to the debutanizer and distillation section. Net gas made in the process goes to the absorber for recovery of butanes. The main functions of the recycle gas are to depress coke formation and to reduce olefin content of the product. A third stream of recycle gas is pumped to the recycle gas storage drum, which is held at about 400 lb. per sq. in. ga. The purpose of this storage vessel is to supply gas to the system rapidly during hydrocarbon repressure of a reactor and thereby minimize pressure fluctuations.

At the end of the on-stream period of a reactor, hydrocarbon feed is diverted to another reactor. The reactor coming off stream is depressured and evacuated to about 25 in. of mercury below atmospheric pressure, whereupon the reactor is repressured with inert regeneration gas. Circulation of regeneration gas is effected by means of centrifugal blowers. Air is constantly added to the stream at controlled rates to maintain constant oxygen content in the gas going to the reactors. Heat generated during catalyst regeneration is removed by two waste heat boilers. When coke combustion has been completed, the reactor is depressured and evacuated to remove inert gas. The reactor is then repressured with feed and recycle gas mixture, and a new make period begins.

The inert gas storage drum shown on the flow diagram has a similar function as the recycle gas storage drum referred to above, namely, to minimize pressure fluctuations in the regeneration gas system during inert repressure of a reactor. The inert gas cooler serves to remove SO_2 and to reduce the moisture content of the gas that is temporarily stored at 400 lb. per sq. in. ga. in the inert gas storage vessel as otherwise corrosion in the latter vessel may occur.

● **Operating cycle.** The unit was at first operated at a 3-hr. cycle consisting of:

On-stream period (2 reactors)		90 min.
Regeneration (1 reactor)		45 min.
Reheat period	(1 reactor)	25 min.
Purge and valve changes	(1 reactor)	20 min.

After operating for several months it was found that the reheat step could be eliminated inasmuch as careful control of oxygen content of the regeneration gas resulted in a sufficiently high catalyst temperature at the end of the regeneration period to effect satisfactory conversion in the following on-stream period. Other factors made it desirable to extend the time for purges and valve changes from 20 to 25 min. The time formerly

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New Lion unit will process wide-cut sour stocks over synthetic catalyst

Lion Oil Company, of El Dorado, Arkansas, has contracted to construct the 70th Houdry-licensed cat-cracker, a TCC unit of 4500 bbl. fresh-feed capacity, with additional capacity for recycling. It will process sour stocks of wide boiling range, over synthetic catalyst.

Naturally, in planning this major post-war improvement, Lion considered the merits of all catalytic cracking processes. Weighing heavily in favor of TCC were:

- **its demonstrated ability to handle heaviest charging stocks;**
- **the extremely small additional capital required for corrosion protection, assuring maximum profit from the processing of low-cost, high-sulfur crudes;**
- **built-in recycling, permitting variation at will of product distribution according to seasonal demands—optimum yields of motor gasoline for the warmer months, proportioned production of distillate heating oil for winter.**

The small TCC unit is not an engineering "guinea pig," but a well-proved design which has been engineered from the ground up, with the same basic design features of the larger commercial TCC plants. Economics, not expediency, have guided its basic planning—have made TCC the catalytic cracking process most favored by operators of small refineries. In cost per ton of steel used in construction, in cost per barrel of high-octane gasoline produced and by other equally decisive standards, the small TCC unit will compare favorably with the catalytic cracking operations of major companies. Details will be furnished gladly to interested refiners.

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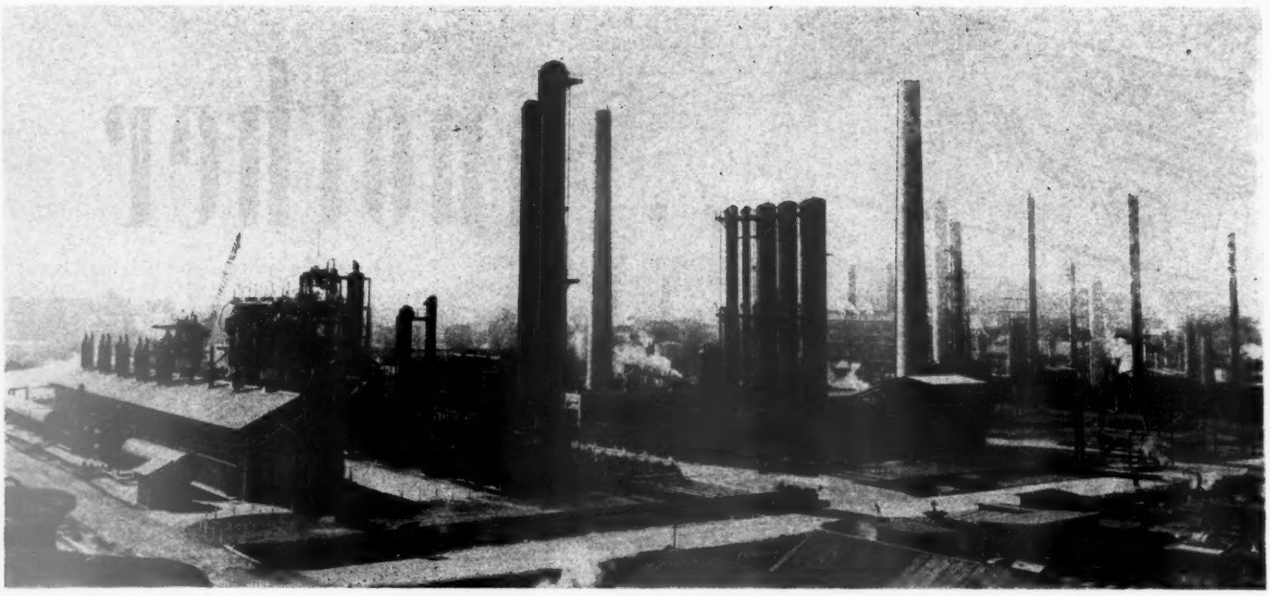

General view of the catalytic reformer plant at the Richmond refinery.

spent in catalyst reheating was added to the make period by putting a third reactor on stream for 20 min. in each cycle.

Control of the operations is effected by an automatic timer of 1200 contact points. In addition, a dormant clock has been provided by which the timer may be stopped at specified intervals and for predetermined periods of time. For example, when stopping the timer for 15 min. 4 times in each cycle, while 3 reactors are on stream and 1 reactor is regenerating, the total cycle length is increased by 1 hr. of which 45 min. are added to the reaction period, and 15 min. to the regeneration period. Thus, for a 6-hr. cycle, time distribution is as follows:

On-stream period, 245 min.
Regeneration, 90 min.
Purges and valve changes, 25 min.

It will be noted that by these steps the make period has been increased to 68 per cent of the total cycle, from 50 per cent normally used in the catalytic reforming process.

● **Reactors.** The reactors of the Richmond catalytic reformer are of special design. They consist of 4 vessels in vertical position each containing 10 catalyst trays of 3-ft. depth. An annular space exists between reactor shell and the outside of the catalyst trays or baskets so that in effect the 10 trays operate in parallel. Feed enters the reactors at the center, flows upward and downward in the annular space, and passes through the catalyst beds discharging into a central collector duct through which the reaction products leave the reactor. Satisfactory feed distribution over the individual beds is assured by orifices of appropriate size situated at the vapor inlet to the central duct.

This type of reactor construction has several advantages. The use of shallow catalyst beds appears to give a more satisfactory distribution of hydrocarbon vapors over the catalyst than does a deep bed. Vapor velocity through the catalyst bed per square foot is reduced tenfold compared to a 30-ft. bed. This is particularly important in catalyst regeneration inasmuch as more regeneration gas can be pumped per pound of catalyst at a given pressure drop through the reactor (or pressure rise at the blowers), thus markedly increasing coke burning capacity of the unit.

● **Catalyst.** The importance of the catalyst, particularly the need for high mechanical strength, high activity, and long life, was recognized early in the process research and development at Richmond. It was soon noted that catalyst made by impregnation of commercial alumina, for example, with ammonium molybdate, as was the usual practice, was deficient in all three respects. The search for a more active and more stable catalyst led to the development by California Research Corporation of a special type of coprecipitated molybdena-alumina catalyst. A commercial plant for manufacture of this coprecipitated catalyst was constructed at Richmond by the Standard Oil Company of California. This has since supplied the catalyst for the Richmond catalytic reformer. Also, at the close of the war, 75 per cent of the catalytic reforming plants in the United States were using this catalyst prepared at the Richmond catalyst manufacturing plant. The coprecipitated catalyst prepared at Richmond is approximately 50 per cent more active than is the conventional impregnated molybdena-alumina catalyst. Its long life and satisfactory mechanical strength are illustrated by the fact that a charge of coprecipitated

TABLE 1. Typical aviation and motor gasoline blend stocks.

	Debutanized aviation gasoline blend stock	Debutanized motor gasoline blend stock
Yield from charge to unit, vol. per cent	77	85
Inspections		
Gravity, deg. API	48.0	48.7
Reid vapor pressure, lb. per sq. in.	2.8	2.3
Bromine no.	2.8	3.1
Color, Saybolt	+30	+30
Gum content		
ASTM	1	1
Copper dish	1	1
After 5 hr. induction (4.6 cc. TEL per gal. plus inhibitor)	1	..
After 4 hr. induction (3.0 cc. TEL, no inhibitor)	..	2
Octane ratings		
F-3 blend. Value (4.6 cc. TEL per gal.) AGAC*	97	..
F-4 blend. Value (4.6 cc. TEL per gal.) AGAC Index No.*	122	..
F-1 (Clear)		86.6
F-1 (+3.0 cc. TEL per gal.)		96.6
F-2 (Clear)		77.4
F-2 (+3.0 cc. TEL per gal)		86.5
Distillation, ASTM—D86		
Start	147°F.	160°F.
10 per cent	202	205
20 per cent	217	219
50 per cent	245	245
70 per cent	264	264
90 per cent	290	298
E. P.	320	356
Per cent rec.	98	98

*At 35 per cent in non-aromatic, 100-octane base stock.

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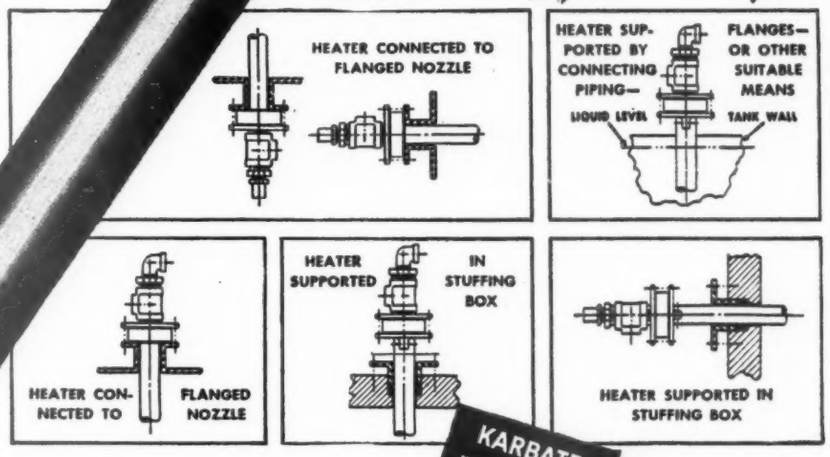

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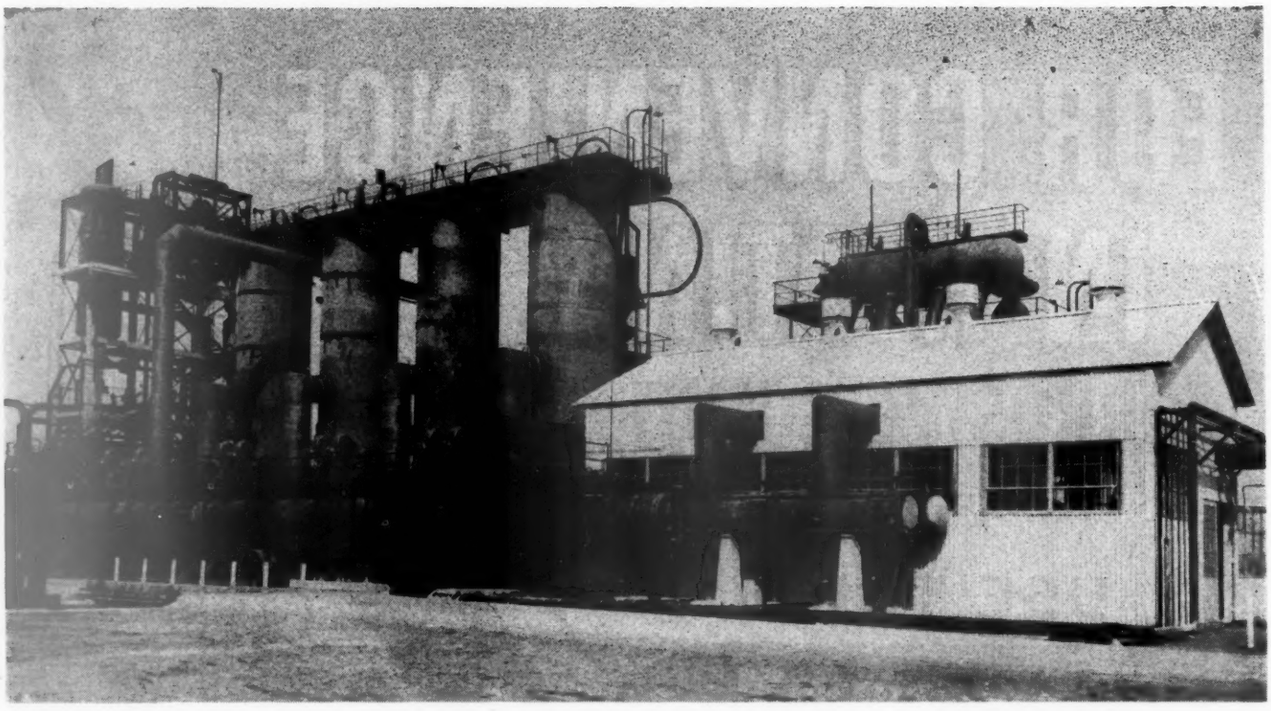

Reactors (left) and inert recirculating blower housing at catalytic reformer plant, Richmond refinery.

catalyst installed in the Richmond catalytic reformer in June, 1944, has since been in use for about 22 months, with substantially no loss in conversion and no detectable fining or physical breakdown of the catalyst pellets.

● **Typical operations.** In the manufacture of toluene, a straight-run charging stock of 180-230° true boiling point range is normally charged to the catalyst section of the unit. As mentioned above, a toluene cut of 85 to 90 per cent aromatic content is produced in first pass operation. This cut is retreated, and the second pass product upon acid treating and rerunning yields toluene of nitration grade quality.

When during the war for a limited period of time urgent need arose for aviation gasoline, it was possible, due to the flexibility of this unit, to change from toluene operation to manufacture of aviation gasoline blend stock without shutting down the plant. It was necessary merely to charge a wider boiling feed stock to produce blend stock consistent with aviation gasoline specifications and with other blend stocks available in the refinery. Typical inspections of the debutanized aviation gasoline blend stock are shown in Table 1. The stock as shown was produced directly from the distillation section without any further treatment. Its low bromine number, high gum stability, and high octane ratings are significant. The blend stock had a Reid vapor pressure of 2.8 lb. per sq. in. For every 100 bbl. of feed stock charged to the catalytic reformer, 77 bbl. of blend stock was produced. Reid vapor pressure of the stock may be raised to 7 lb. per sq. in. by addition of 21 bbl. commercial isopentane, thus producing 98 bbl. of aviation gasoline for every 100 bbl. of feed charged to the unit. The mixture of isopentane and blend stock with 4.6 cc. TEL per gal. had an F-3 (lean) rating of 100; its slightly low rich rating was adjusted by addition of cumene or other rich blending agent.

Table 1 also shows typical inspections of a motor gasoline blend stock. In this operation, normally a somewhat heavier charging stock is employed, of approximately 60 CFR motor method octane number.

● **Special products.** In addition to the manufacture of motor gasoline, the catalytic reformer has definite possibilities in peace-time economy. The Richmond unit is considered an important contributor to Standard Oil Company's production of chemicals for its subsidiary, Oronite Chemical Company, For example, as stated, xylenes are produced as by-products in the manufacture of nitrate grade toluene. Selection of charging stocks of approximate boiling range and use of appropriate operating methods make it possible to increase markedly production of xylenes and C_9 and higher aromatics. Manufacture of low analine point thinners containing a high percentage of toluene and xylenes can be achieved without difficulty, and aromatic thinners of higher boiling range can be produced also.

The preparation of relatively pure xylene isomers is an interesting development that has been carried out in commercial scale for some time. A whole xylene cut can be made substantially free from non-aromatic constituents, which can be further processed to separate isomers of about 95 per cent purity. Table 2 shows typical inspections of xylenes produced commercially.

Ortho-xylene made at the catalytic reformer is being used at Richmond to produce phthalic anhydride by catalytic oxidation. The Richmond phthalic anhydride plant is unique in that it is the first commercial unit using ortho-xylene, instead of naphthalene, as charging stock. The varied use of phthalic anhydride in the chemical industry for manufacture of alkyd resins, di-alkylphthalates as plasticizers, insect repellents, and its function as basic material in the dye industry promises further expansion of the market for ortho-xylene. ★ ★ ★

TABLE 2. Typical inspections of xylenes.

	Ortho-xylene	Meta-xylene	Para-xylene
Isomer, vol. per cent	90	95	95
Specific gravity, 60°/60°F.	0.874/0.881	0.869	0.864
Boiling range, °C.*	142/145	138/143	136/141
Boiling range, °F.	288/293	280/289	277/286
Color, Saybolt	+20	+20	+20
Acid wash color*	4	10	6
Cloud point at 30°C.	None	None	None
Copper corrosion*	Passes	Passes	Passes
Acidity*	None	None	None

*Barrett method.

*This battery of Ingersoll-Rand gas-engine-driven gas-compressors, totalling 4200 horsepower, is installed in a large aviation gasoline refinery on the Pacific coast.**

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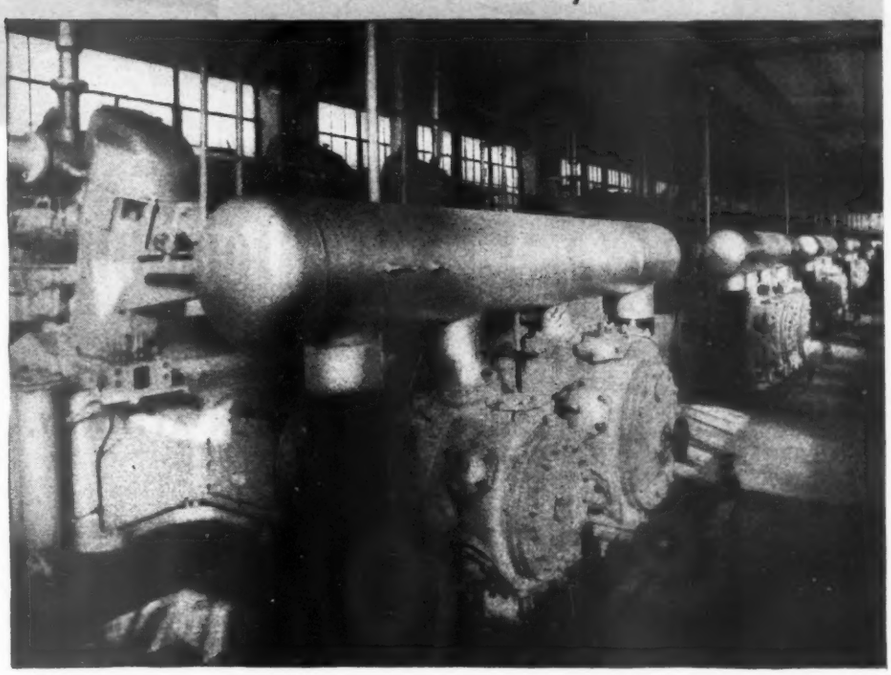

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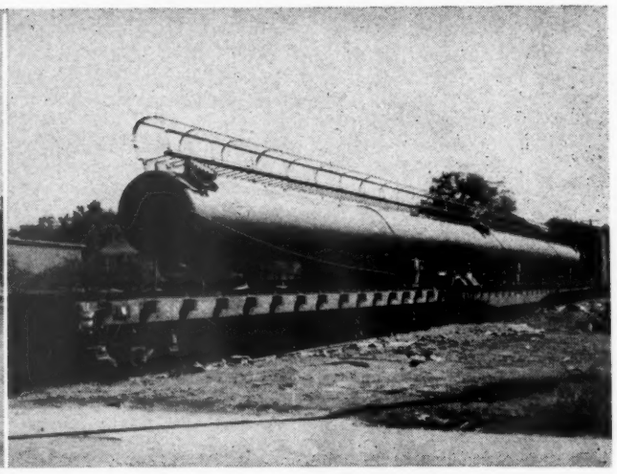
The 145-ft. deisobutanizer tower arrives in Magnolia, Arkansas, and is spotted on a side track for unloading.

Extreme length of the tower called for three flat cars to be used, the center one serving as an "idler" car.



Erecting a 145-ft. Deisobutanizing Tower

EXCLUSIVE *Petroleum* Engineer **Picture** *Story*

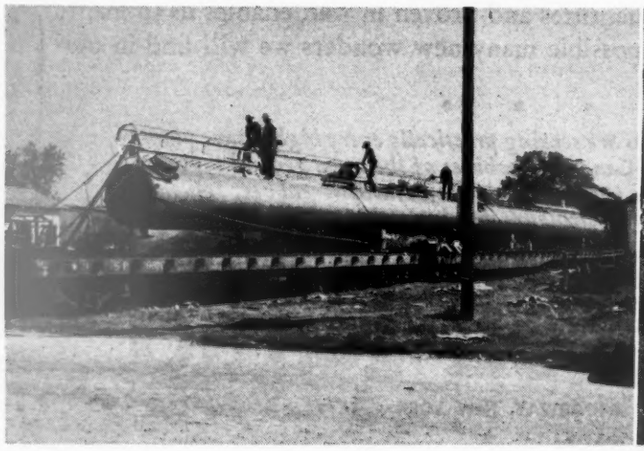
By **DON ATTAWAY,** Arkansas Fuel Oil Company

WHEN the Arkansas Fuel Oil Company constructed its Columbia gas treating plant near Magnolia, Arkansas, one of the special problems was the transportation and erection of a 54-in. by 145-ft. fractionating column to be used as a deisobutanizer. Larger and taller columns have been fabricated and erected, but this particular job involved transporting the column from the nearest railroad, over some seven miles of country road to the plant, without special equipment, and erecting the tower with gin poles that were shorter than the tower by 65 ft.

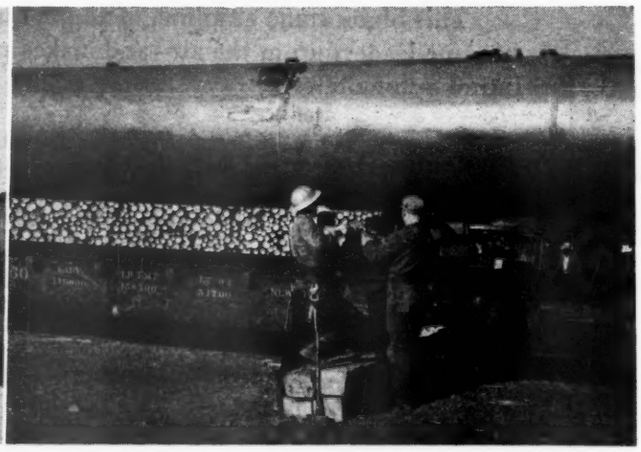
The job was accomplished, however, with remarkable speed and some ingenuity. Two local trucks were utilized for the hauling and the accompanying pictures present graphically the manner in which they performed the job.

The raising of the tower was a rather delicate task. Actually the raising lines were tied onto the column as low as space would permit and the hollow base of the tower loaded with kegs of bolts and nuts. The balance was so perfect that a man could easily move or lift the bottom with one hand, and while thus suspended the tower was guided into exact position on the foundation bolts. Accomplishment of the job showed great skill.

To facilitate unloading and hauling, it became necessary to remove the caged ladder from the long column.



The tie-down straps and cables were next removed and then blocking removed from the center section.



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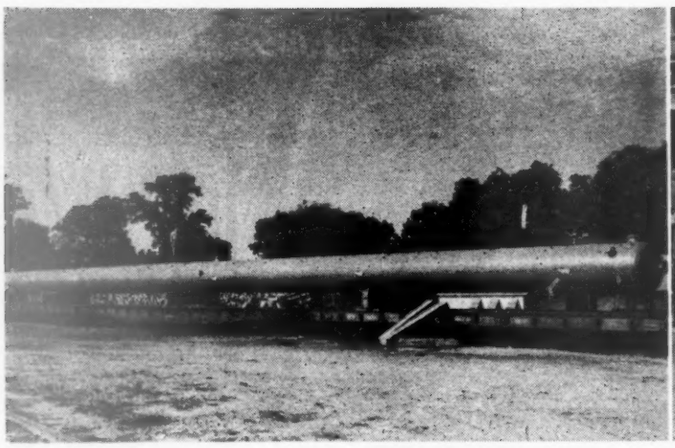
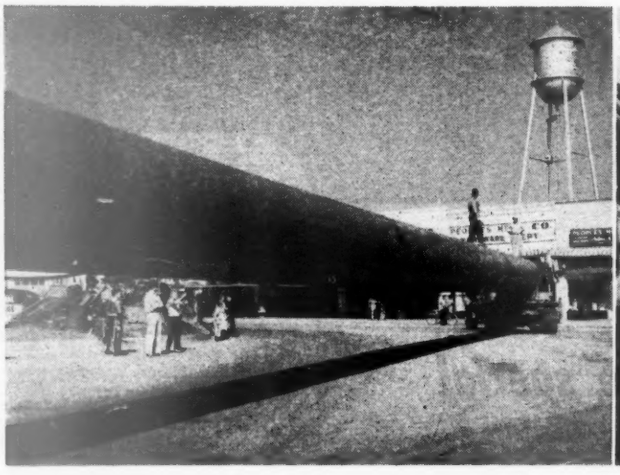


The tower was made ready for skidding from the flat cars and two trucks were obtained to handle the loading for the trip to the plant.

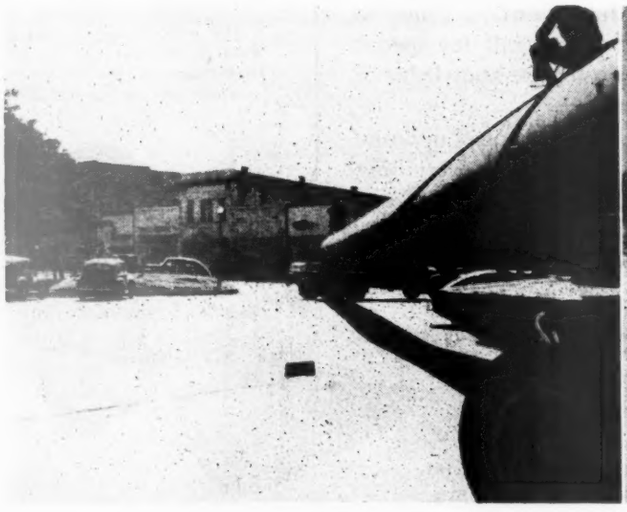
It was loaded with the top on the bed of the lead truck and the base on the bed of the rear truck, which had to make the whole trip in reverse.



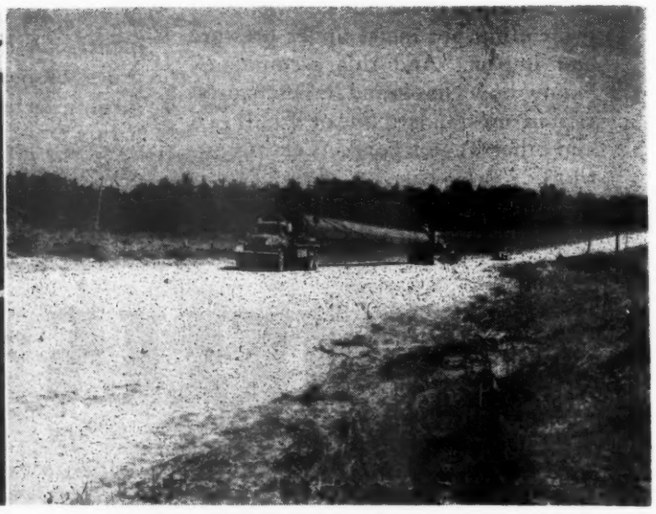
Due to the tower sagging in the center, it was necessary to string a double cable underneath the entire length of the tower and support the center section.

First obstacle was encountered in passing through Magnolia where there was difficulty in executing a turn at the public square on the way to the highway.

By the process of see-sawing and backing the tower was finally headed out the highway. A crowd of spectators gathered to observe this interesting maneuver.



Once on the road the movement was not difficult, but progress was slow as perfect coordination between the lead truck and backing rear truck was necessary.



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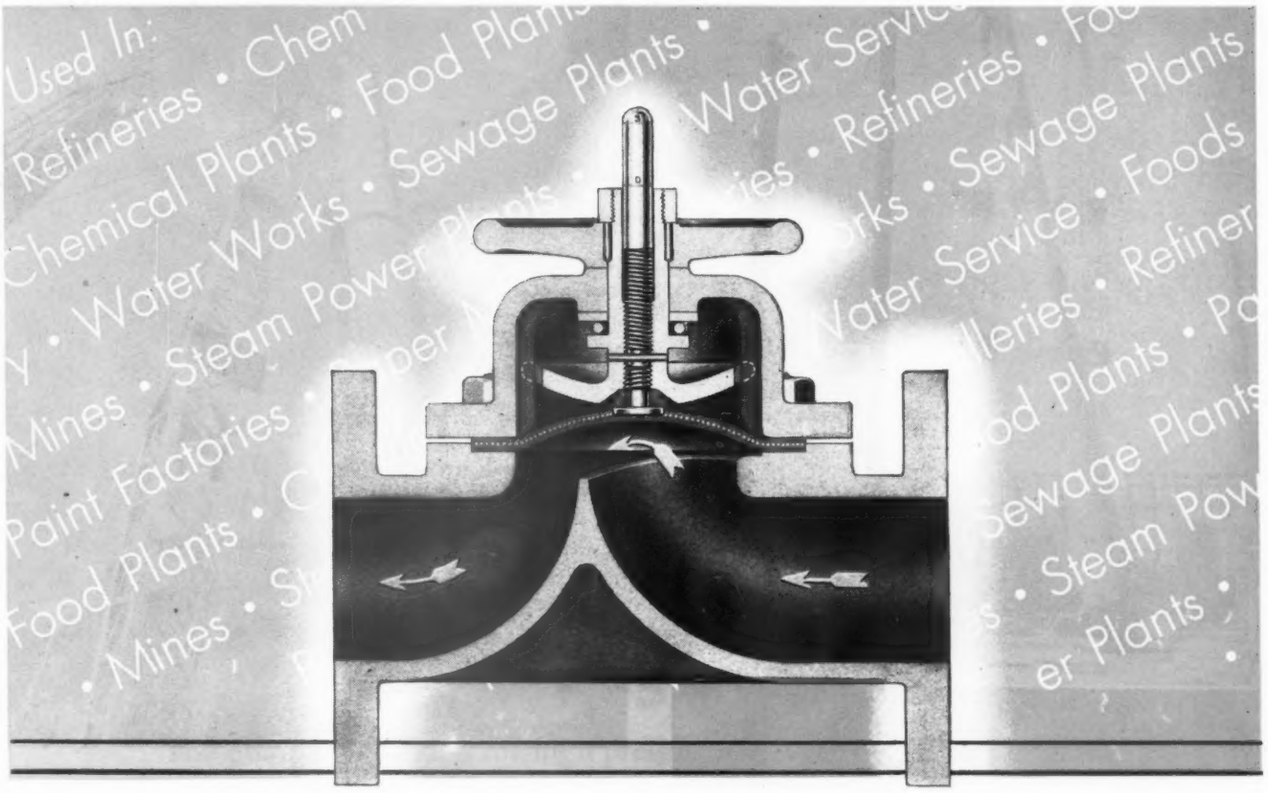

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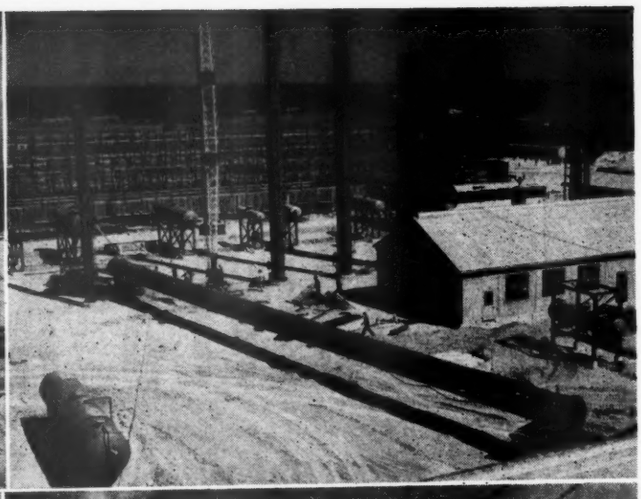

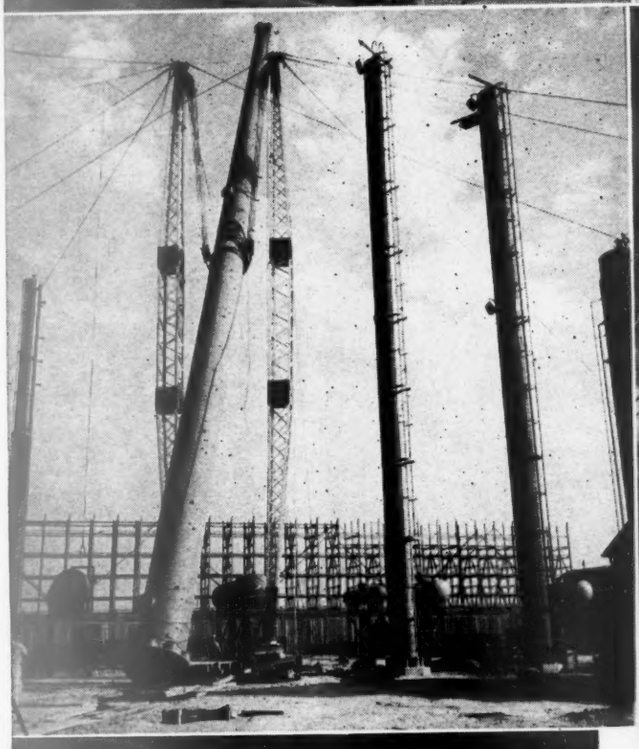

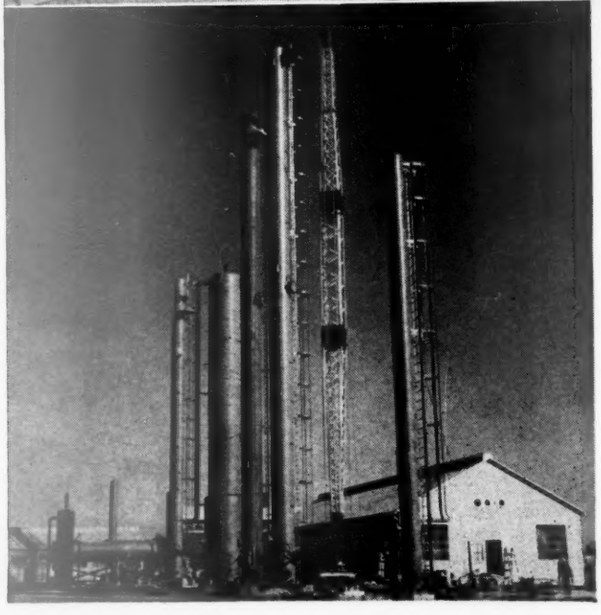

Top left—In the meantime a steel gin pole had been erected at the plant, near the foundation, to raise the tower.

Top right—After the trucks reached the plant yard the column was moved into a position where gin pole lines could take hold near the middle of the tower.

Center left—Extreme length of tower and shortness of gin pole made it necessary to erect a second gin pole so the bottom section of the tower could be weighted and the lines tied lower.

Center right—With proper amount of weight loaded in the bottom of the tower and the lines fastened well below center of the column, the job was carefully and skillfully completed. As the tower moved upward the base skidded toward the foundation.

Left—The tower moved easily into place and with one slight lift hovered above the foundation bolts and neatly descended into exact position. The caged ladder was lifted into place beside the tower and bolted into position after the second gin pole had been dismantled. THE END

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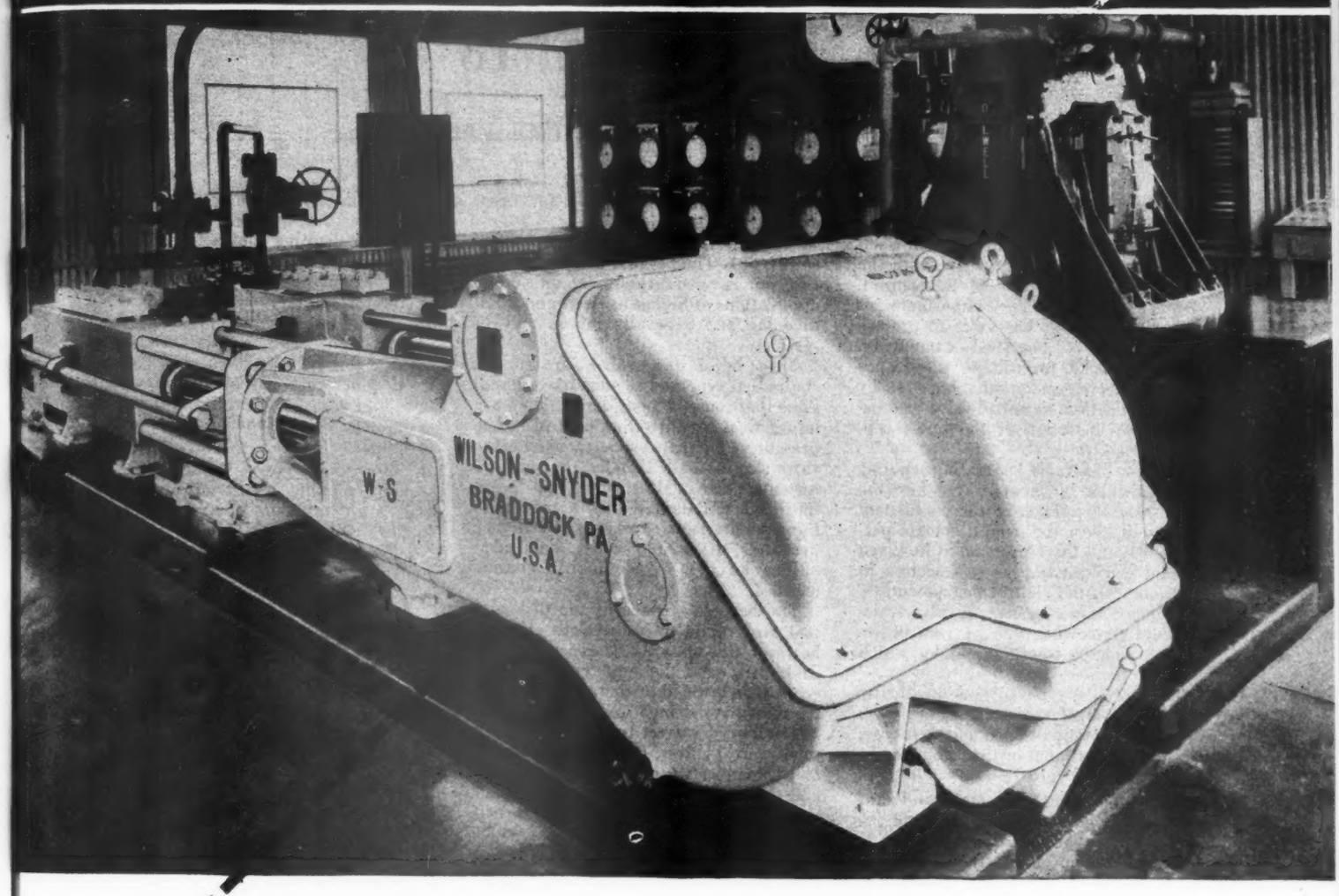

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The pump illustrated is the high pressure type for Recycling and Polymerization Processes. Power drive can be by steam engine, electric motor, or internal combustion engine.

The range of sizes available assures a selection that will be most economical for your capacity and pressure requirements. Units are in service at pressures up to 2,000 lbs. per sq. in.

Power frames are one piece totally enclosed, with roller bearings and oil-bath lubrication.

Fluid ends can be furnished of cast or forged steel.

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SELECTION AND APPLICATION OF REFINERY INSTRUMENTS

By **ALFRED KRIEG***
Socony-Vacuum
Oil Company, Inc.

PART 5—DIAPHRAGM CONTROL VALVES

THE diaphragm control valve is a vital part of the control equipment; however, it is often given little consideration when selected for use in conjunction with the control instrument.

EXCLUSIVE

The importance of the valve to process control cannot be overemphasized, for without the proper performance characteristics required by each application, a control valve can discredit the operation of the finest controller.

Certain desirable operating characteristics must be incorporated into the valve assembly. Each of the component parts will affect the overall control performance and therefore should be given careful consideration as to selection in relation with the control instrument.

The selection of a control valve is dependent upon the type of control required, and the conditions under which it must operate.

There are 2 types of pneumatically operated control valves in general use, the quick opening or open and shut type, and the proportional or throttling action type (balanced valve).

● **Open and shut type.** Open and shut control may best be described as the reaction of the valve that in operation is either wide open or tightly closed. This action is generally obtained with single, bevel-seated valves, or with balanced poppet valves for sizes over 2 in. As the flow characteristics of the valve in this type of control are not critical, the most important consideration is the proper size of valve for the job. This method of control has greater use where batch processing is employed and for dryer applications, etc.

● **Bevel-disk—single seat (open and shut type).** The beveled disk type valve, Fig. 56, is used principally on simple applications of high sensitivity and small time lag and generally for on and off service.

Most bevel disk valves are of the single seat type and as such have limitations that must be considered. They are impractical for throttling control if line pressures fluctuate widely, unless the valve size is small. Usually, they are not recommended in sizes over 2 in., due to the large unbalanced disk area, unless the line pressures are low. For higher pressures, the double seated "balanced" valves have more desirable characteristics.

The beveled surface of the disk and seat are ground to insure tight closing; however, this must not be expected if the disk and seat become corroded or eroded, or if the fluid contains solid matter that may become wedged therein.

● **Balanced valves.** In all sliding stem type control valves, fluid pressure in the body creates a thrust on the inner valve, and the double ported body is designed to minimize the effects of this thrust. The inlet and outlet fluid pressures tend to balance themselves by acting both upward and downward on the 2 valve plugs (see Fig. 57) hence the term balanced valve. The balanced valve feature also permits operation at high pressure drops through the valve, as the force created by the diaphragm motor does not have to overcome the full force by the line pressure acting on the plug or disk, as is the case in the single seated valve, and for the same reason larger valves can be operated without resorting to the larger diaphragm motors. With wide variations in temperature, the stem connecting the 2 seats of the plug contracts or expands linearly a different amount than the valve body. When the valve is in the closed position, therefore, one valve plug seats and prevents the second plug seat from closing tight. This results in a small leakage through the valve, which varies up to 4 per cent of the valve maximum flow, and in cases where a tight shut off is required a single seated valve must be installed.

● **Throttling control type.** In the petroleum refining industry where processes are continuous, control conditions such as demand and transfer lag must be overcome by the proportional type control instrument and a throttling or proportional control valve.

In any valve of this type, the inner valve or plug is always floating and being continually adjusted to compensate for variations in process conditions. To accomplish this, the valve must have definite flow characteristics, be properly sized, and be correctly installed in the pipe line.

The usual design of a valve body for throttling or proportional control is similar to that shown in Fig. 58 and is known as the double ported or balanced type. There are also valves designed for special control applications such as the percentage piston plug type, the angle type with a single seated parabolic plug, and the needle plug type.

● **Valve plugs.** The types of valve plugs or disks most commonly used for throttling control are classified as follows:

(a) V-ported type.
(b) Shaped plunger type.
(c) Low flow rate type.

*Alfred Krieg is supervisor of Instrument Department at Socony-Vacuum's Paulsboro, New Jersey, refinery.

FIG. 56

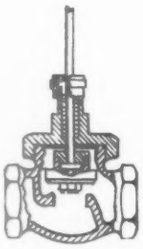


FIG. 57

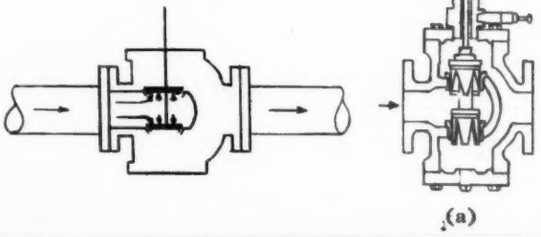
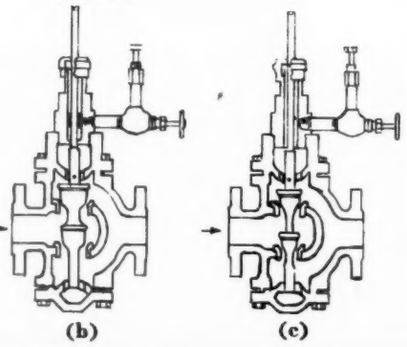
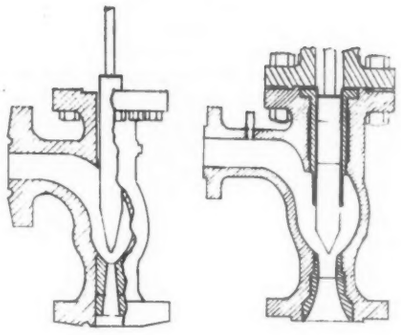


FIG. 58





(a) (b)

FIG. 59

● **The V-port type.** This type of inner valve construction is adequate for most applications where widely varying rates of flow exist and where full throttling control over the entire flow range must be maintained. Its capacity is as high as any of the characterized valves and it has the greatest controllable range. (See Fig. 58[a]).

The improved *percentage* characteristics of V-port disks or plugs over the bevel disk construction are accomplished by the addition of a skirt having several V-shaped ports that create a relationship of constantly increasing port openings for each unit lift, under conditions of constant pressure drop. These features make this type highly desirable for most difficult control applications.

Double seated V-port valves are available in a wide range of sizes and materials. The seat rings and plugs or disks are renewable and the valve may be easily converted from the "air to close" to the "air to open" type. Where high pressure drops exist, they are supplied with top and bottom guides and bushings to assure proper alignment.

● **The ratio plug.** The ratio plug (Fig. 58[b]) is designed so that each uniform increment of valve lift will result in a change in flow rate, which is practically a constant percentage of the flow rate existing prior to each change in lift. The percentage characteristic is desirable for difficult control applications where large load changes are involved.

The ratio plug controls rate of flow by means of variable port openings determined by the curvature of the plug proper. Its shape minimizes the tendency to spin or wire draw, because of the absence of projections or wings. It should not be used, however, for fluids with suspended solids because of its small clearance at low lifts. In this type also the plug is guided top and bottom to give proper alignment without friction and to minimize erosion of plug and seat rings.

● **The throttle plug.** The throttle plug, similar in shape to the ratio plug, gives larger flows at low lifts than the V-port or the ratio type plugs. This type (Fig. 58[c]) was designed for greater resistance to wear under severe conditions. It has greater port area at low lift, which overcomes a tendency to "coke" or to become fouled, and will handle large pressure drops particularly well.

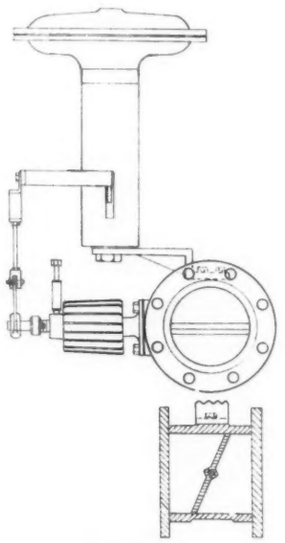


FIG. 60

There is no tendency for this plug to spin due to the absence of projection wings or ports.

This valve will also permit foreign particles such as pump packing, welding rod, metal chips, etc., to pass through without interference.

In general, this type of valve is satisfactory for many throttling control applications whether the flowing medium may be light hydrocarbons or a heavy viscous tar.

● **Angle type valve with Venturi throat and tapered plug.** A control valve designed to eliminate eddy currents, deposits of coke and erosion, and to provide a maximum capacity with a minimum pressure drop is illustrated in Figs. 59 (a) and (b).

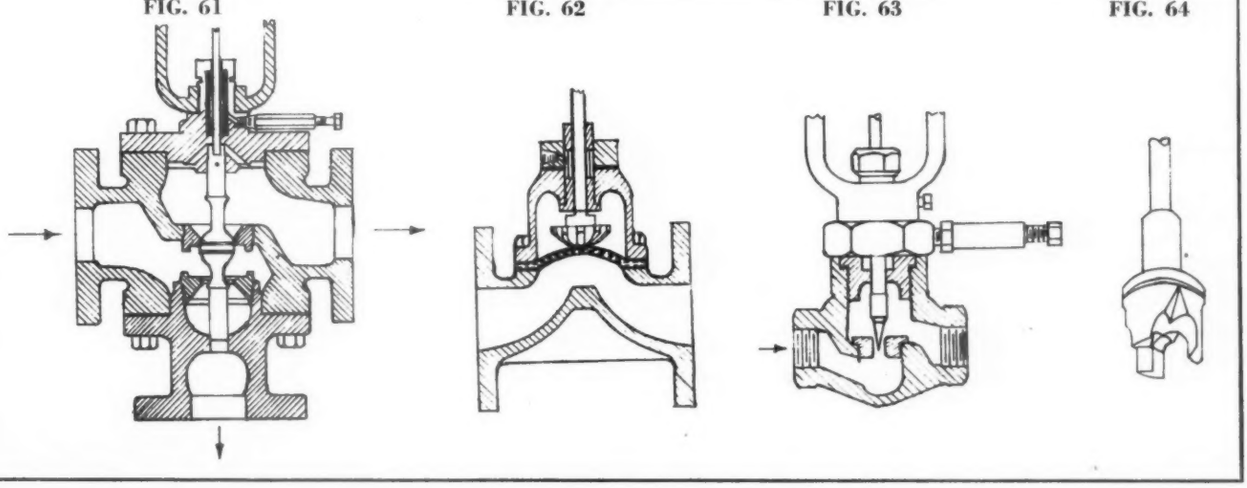
In this type valve the flow is directed by a gradual approach into the Venturi throat and thence discharged directly through the outlet. This design has a tendency to increase the velocity through the body, creating a scouring action, and thereby reducing the possibility of coke or other material formation.

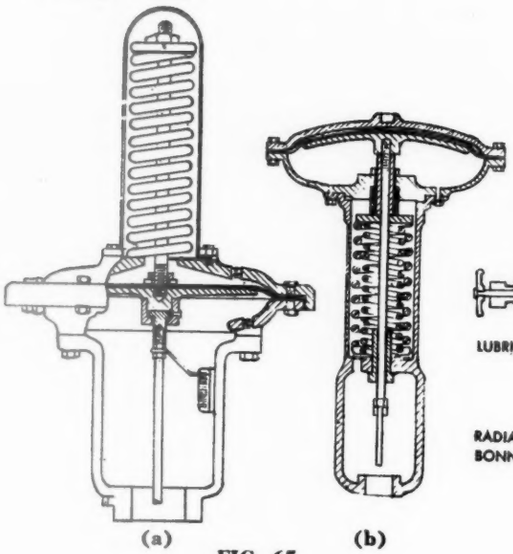
A long tapered plug is suspended in the center of the flow and extends about half of its length into a removable stainless steel liner. This plug design offers a minimum of resistance to the flowing medium.

Provision is made for radiation fins or bonnet for high temperatures and for flushing to prevent the collection of coke particles on the plug or liner where extremely difficult conditions make this necessary.

Operating mechanisms for this valve include many devices. They are available for operation by the usual diaphragm air motor, hydraulic or pneumatic piston, or by electric power positioners. In the diaphragm type, a continuously connected handwheel and indicator assembly may be attached in the superstructure. The valve stem and plug may be operated by the handwheel in cases where manual control is necessary, and by presetting the indicator the travel of the plug may be fixed to any desired range of travel. Closing or opening of the valve beyond set limits may

FIG. 61 FIG. 62 FIG. 63 FIG. 64





(a) (b)

FIG. 65

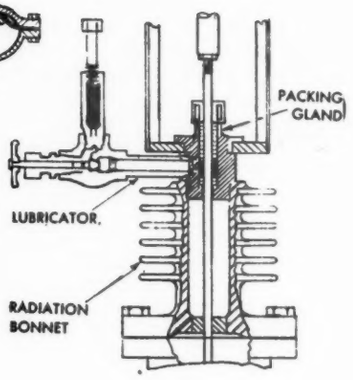


FIG. 66

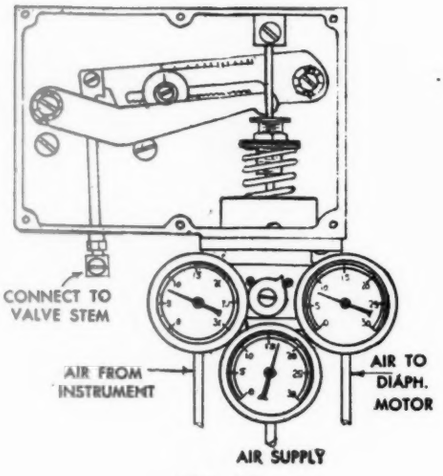


FIG. 67

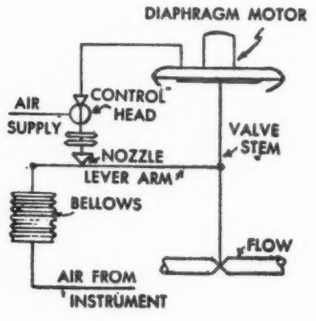


FIG. 68

be prevented in case of air supply failure in this manner.

This type of valve has been used extensively at the Paulsboro Refinery for applications where control of flow is necessary in unit transfer lines having pressure drops as great as 950 lb. per sq. in. ga. They are also in use on hydrocarbon and acid services where the fluid is highly volatile and the pressure drops are exceedingly high.

● **Butterfly valves.** Butterfly valves are highly suitable for the economical control of large flow volumes of air, gas, water, oil, or steam in lines or ducts, and on low or medium pressures, where a low pressure loss is desirable. (Fig. 60).

Although they are adaptable to automatic throttling type control in some applications, they may also be applied to special pneumatic or electrical controllers by using floats, levers, and other linkage devices.

An outstanding advantage of this type of control valve is its ability to pass pulpy, viscous, and semi-solid materials.

Theoretically, the butterfly valve is balanced; however, this is not strictly true, and it requires the power of the operating device to counterbalance this condition. The degree of unbalance is determined by velocity effects on the wing or gate when the flow is deviated into 2 channels. This unbalancing effect is not noticeable in intermediate positions of the gate, but it is quite marked near the open and closed positions, and to minimize lags the operating mechanism must be sufficiently powerful to overcome these effects.

● **Three-way valve.** The three-way control valve shown in Fig. 61 has found increasing usefulness in cases where a method of bypass control of the flowing medium may be employed. Many valves of this type are applied on heating and cooling installations particuularly where the pressure drop through the vessel is low. Obviously, sizing of the valves in such cases is very important. A typical application on a condenser-receiver is shown in Fig. 9, Part I, of this series.

● **"Saunders" valve.** A control valve of simple design for acid or other corrosive service is shown in Fig. 62. This valve has no plug or seat rings. The operating principle is based on the compression of a tough, resilent diaphragm between 2 metal surfaces.

The diaphragm material is of course dependent upon the temperature and the flowing medium. In addition to closing the valve, the diaphragm also seals the fluid from the working parts in the bonnet. When repairs are necessary, the valve may be left in the pipe line, the diaphragm replaced, and the valve is again ready for service within a short period of time.

On acid service the bodies are supplied in standard metals and are available with special linings of rubber, lead, or glass. They are used on low velocity flow applications for dirty service where temperature conditions permit.

● **Low flow rate valves.** Low flow rate valves are designed to provide small port area changes generally unobtainable with the other types. These valves, the needle or tapered plug type (see Fig. 63) are available in inner port diameters from ⅛ in. to ¾ in. There are many modifications of the needle type and many special shapes of plugs. One valve "family" available incorporates the percentage piston principle. The design of the plug is of the single seated or piston type with a porting arrangement consisting of 5 milled slots. (See Fig. 64.) Three large slots are arranged symmetrically about the perimeter. A fourth cut is made running into the large slot starting at some distance from the seat and the fifth cut is milled starting near the seat and into the large slot.

It is recommended by some manufacturers that the flow be brought in over the seat of the valve. This results in the flow through the port being directed downward away from the valve trim. For applications with high pressure drop and small flows, forged steel angle bodies are available to reduce further a tendency to erosion.

The free diameter of the diaphragm is large on these valves, which gives an effective area providing extra power to the motor and reducing the effect of unbalance area of the single seated piston to a minimum.

This design and construction with some manufacturers, however, does not permit the reversal of valve action as with the standard types of V-port and parabolic plug valves. A superstructure is provided for each of the reverse and direct action type valves.

The low flow rate valves as described above are particularly useful for pilot units where flow rates are exceedingly small.

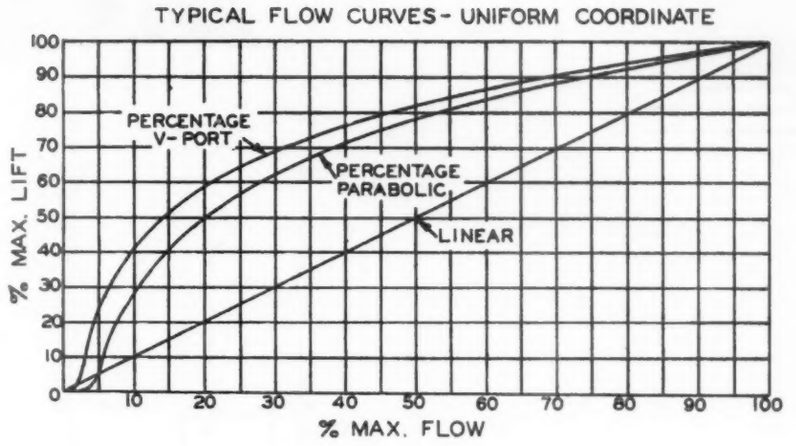
Depending of course on the pressure drop, these valves may be used for controlling quantities as minute as 1 gal. per min.

● **Super-structures.** The design of the super-structure of the control valve, which houses the diaphragm motor assembly, the calibrated spring, and the valve stem, should be carefully considered in the selection of a control valve. The force characteristics of the diaphragm motor have an important effect on the valves' ability to control. (See Fig. 65[a] and [b]).

In an automatic control application, air from the primary control instrument is applied to a pressure-tight chamber of the diaphragm motor assembly. The product of the air pressure and the area of the flexible diaphragm creates a force that causes a downward movement of the diaphragm. As the diaphragm moves downward under this force, the calibrated spring is compressed, creating an opposing force that increases as the spring is further compressed until a state of equilibrium is reached. For each increment of air pressure that is applied to the diaphragm, there is a corresponding position to which the valve is moved.

In order to position the valve plug with accuracy and meet the demand of the control unit, the diaphragm motor must have sufficient power to overcome all the frictional forces plus the thrust on the valve plug caused by the pressure of the flowing fluid. The diaphragm should be constructed of a strong yet flexible material and should be so designed to produce a constant effective area throughout the entire travel. It must be strong enough to withstand reasonable shock yet flexible enough to insure sensitivity and smooth action. A molded or formed diaphragm is supplied by some manufacturers to give a maximum of flexibility and maintain greater strength with lighter weight.

The compression spring should be of such design that a maximum of straight line characteristics are obtained. In order to eliminate hysteresis, the spring should be as long as possible and strong enough to position the diaphragm accurately for each increment of air pressure applied to the diaphragm.



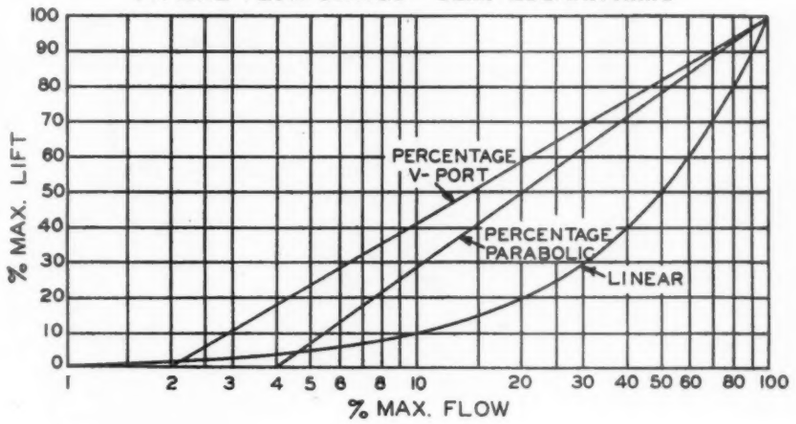
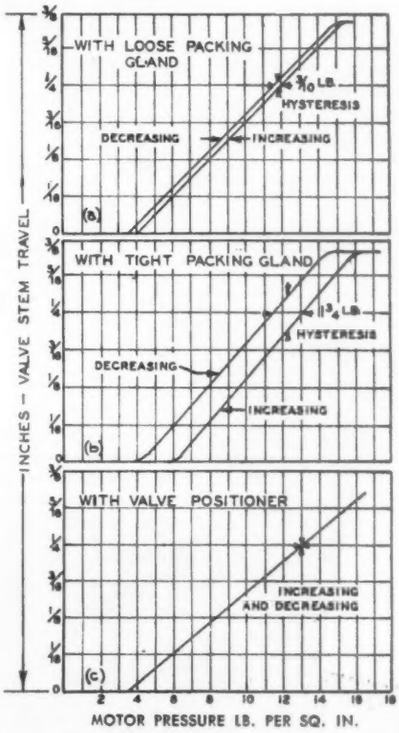


FIG. 70

FIG. 69



● **The packing gland.** The packing gland, or stuffingbox, of the control valve is designed to seal the fluid flowing through the valve body while permitting valve stem motion with a minimum of friction as shown in Fig. 66. It is mounted on the head flange of the valve body with a sealing gland around the valve stem, which is packed with special packing material. The packing material used is determined by the temperature and the corrosive characteristics of the fluid being controlled.

● **Valve lubrication.** In order to reduce friction and to aid in sealing the gland, special valve lubricants are used. A wide variety of lubricants, suitable for temperature ranges from minus 50°F. to plus 1000°F. and for every type of service, are available. If maximum operating efficiency is to be attained, it is essential that the recommendations of the lubricant manufacturer be closely followed when selecting the proper valve lubricant.

● **Radiation bonnets.** Where service temperatures above 500°F. exist, excessive drying of the lubricant often results, causing the valve stem to stick or bind. For such application, an extension bonnet with the packing gland at the top and radiation or cooling fins along the length is recommended (See Fig. 66). This dissipates a large percentage of the heat before it can reach the packing gland.

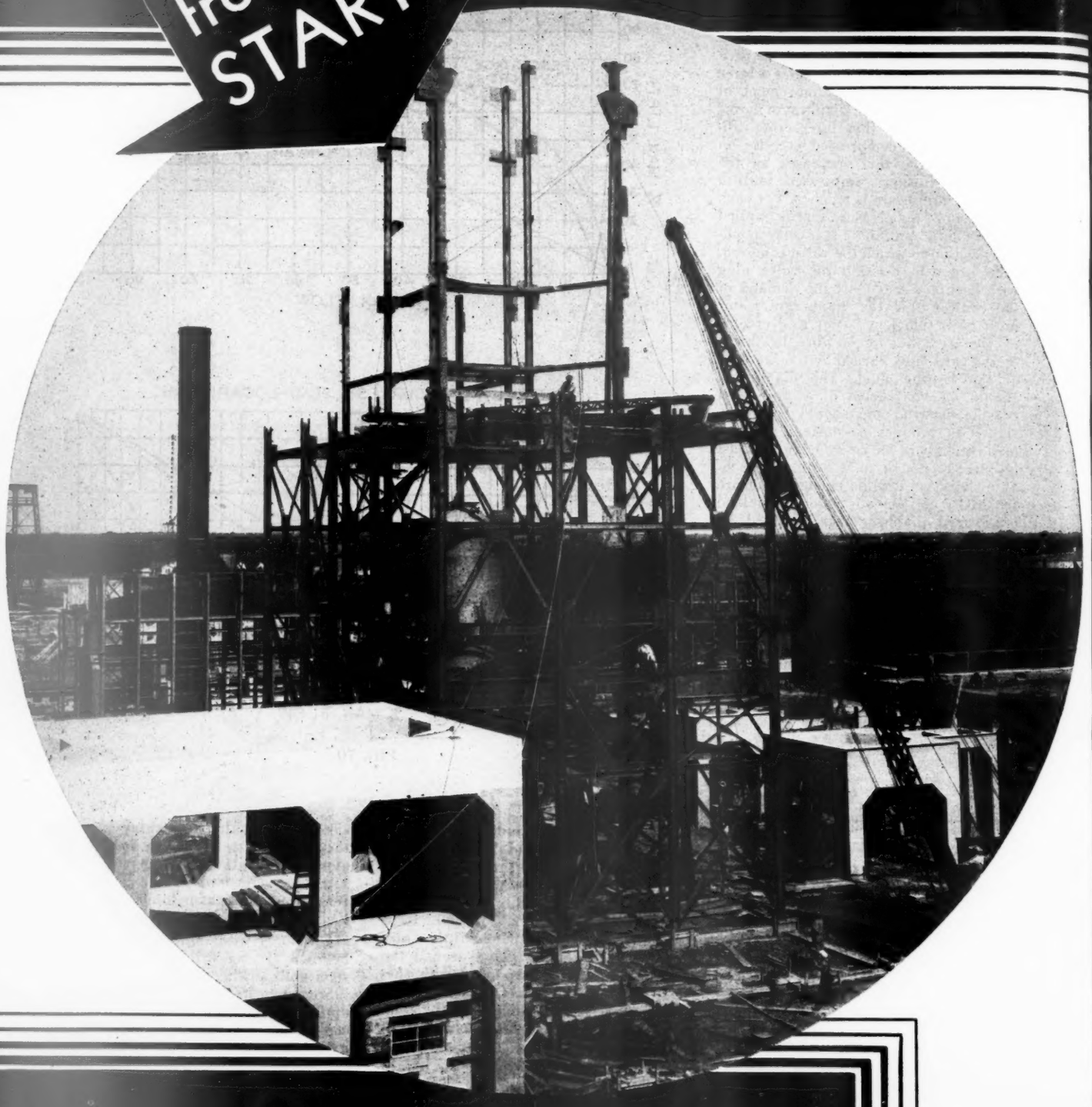
On fluids with flowing temperatures below 32°F., ice will form on the valve stem and packing gland, and cause the lubricant to harden. For valves on cold applications, radiation bonnets with cooling fins are also required. Thus the ice coating can easily be removed from the bonnet and heat can be more readily absorbed from the atmosphere or from heating coils.

On highly corrosive fluids, the radiation bonnet assembly is often used with a sealing gland at the base of the bonnet as well as at the top. This affords added protection against leakage.

● **The valve positioner.** The throttling type control valve must respond to the very small changes in air pressure transmitted to its diaphragm motor from the automatic control instrument. If the valve response is not accurate and consistent, cycling in the system may result.

The diaphragm action must not only overcome the diaphragm spring pres-

from START



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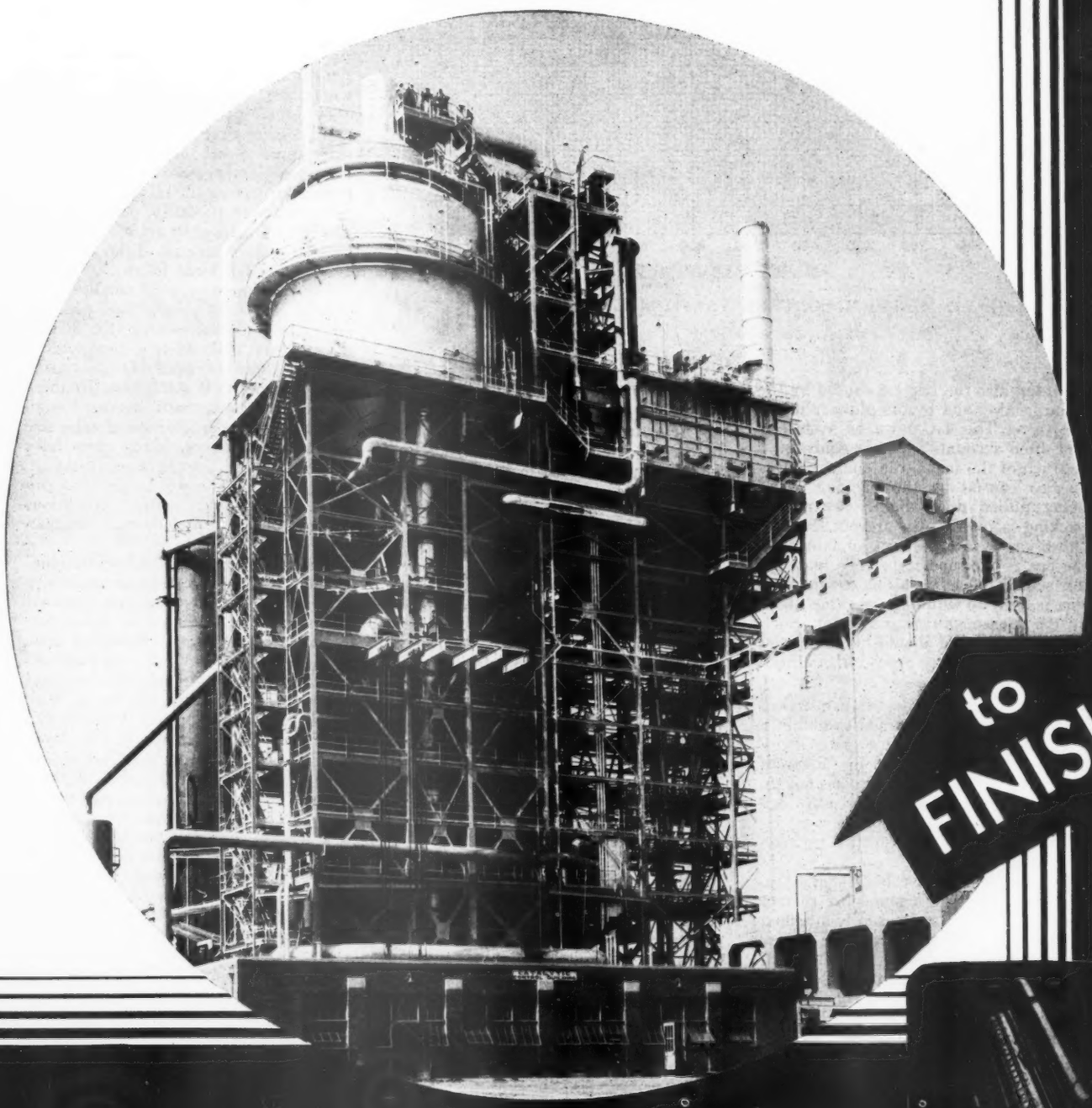

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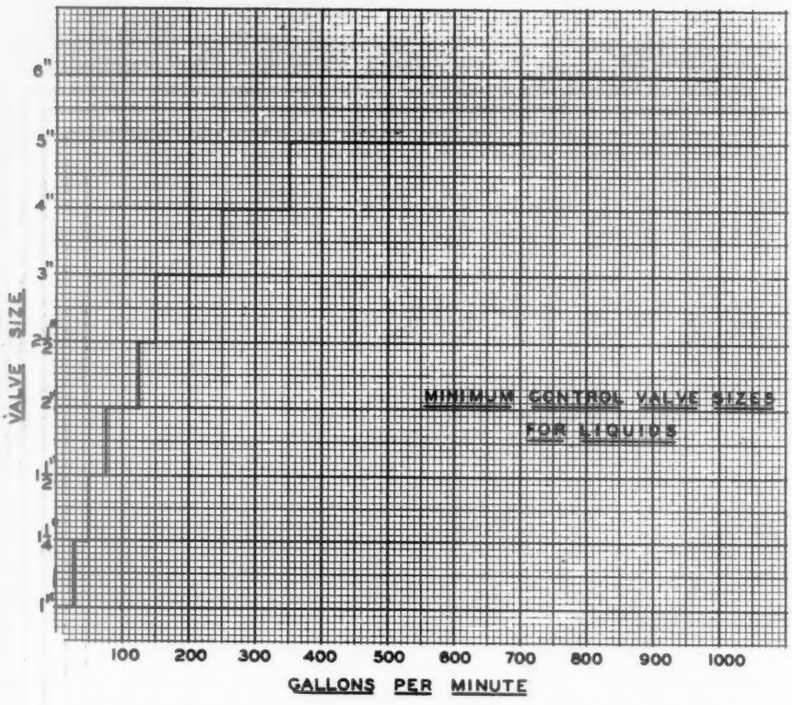

FIG. 71. MINIMUM CONTROL VALVE SIZES FOR LIQUIDS.

sure, but also the friction caused by the stem packing and by the plunger inside the valve. This is known as hysteresis and often accounts for poor control.

Much of the friction in control valves is also caused by the packing gland being pulled down tightly when new packing is required to prevent leakage. Other causes are the lack of lubricant, the use of improper types of grease, or the seizing effect resulting when pressure is built up within the packing gland by the grease gun or lubricator. Such hysteresis can and should be eliminated by good maintenance procedure and routine inspection.

Control valves with characterized ports or plugs are designed to obtain a definite flow change for a given increment of valve travel. If the inherent hysteresis or friction is great enough, small changes in the air pressure applied to the diaphragm do not cause an equivalent response, resulting in inaccurate control.

By means of a valve positioner (Fig. 67) the valve is forced into the correct position. This device is usually attached to the valve super-structure. The air pressure from the controller is not connected into the diaphragm motor, but is connected to a bellows, or hydron, which positions a baffle within the positioner, as shown schematically in Fig. 68. A nozzle actuates a relay air valve, supplied from an auxiliary source of air and is attached by linkage to the valve stem or diaphragm. From the pilot, the diaphragm is either inflated or deflated as required by the nozzle and baffle relationship to bring the valve stem and plug to the correct position. By using a valve positioner, very accurate positioning of the plug is provided and the hysteresis minimized. (See Fig. 69).

● **Selecting valve size.** The selection of correct size as determined by a formula, alignment chart, or valve slide rule is based on the assumption of full knowledge of the flowing conditions. In practice, however, one or more of the flowing conditions are frequently arbitrary or indefinite and the evalution of this arbitrary data requires experience and good practical instrument engineering judgment in determining the final valve size. One not experienced in selecting valves may have a tendency to be on the safe side when calculating the size of a valve, which, in turn, results in poor control. It is erroneous to select a valve size on the basis of minimum pressure drop as is customary in calculating pipe size.

The quantity that any valve will pass depends upon the pressure drop across the valve. The pressure drop that is used in calculating the size of a valve should be that which actually will exist in service. In a back pressure or reducing valve, the drop across the valve is quite accurately known and the selection of the proper valve size is relatively simple. In a large percentage of automatic control applications, however, the problem is more complex and determining the valve size requires a complete analysis of the system.

The control valve must create a pressure drop that will maintain the quantity of flow called for by the controller. This pressure drop must be of such magnitude that sufficient driving force is available to assure constant flow lift characteristics of the valve for all rates of flow within the linear portion of the valve's flow-lift curves. (See. Fig. 70). When engineering data are available, the design pressure drop across the valve is often expressed as a percentage of the friction drop in the total system. When conditions permit a good rule is to take the sum of all the frictional losses in the system, exclusive of the control valve to be installed, and make the pressure drop across the valve approximately 50 per cent of this total. On many installations where there are extremely high pressure drops in the system this is not possible and a lower percentage drop must be utilized. In no case should the pressure drop be less than 15 per cent of the total system drop. As a valve regulates flow by absorbing and giving pressure drop to the system, this low percentage drop is only permissible where there are small variations in flow.

On other installations where the system pressure drop is relatively low, the valve must absorb nearly all the drop. For example, there are cases where flow from a furnace at 1000 lb. per sq. in. ga. enters a tower at 300 lb. per sq. in. ga. The control valve must absorb the majority of this drop because of the relatively low system frictional losses.

There are many special conditions on critical products where the pressure drop across the valve causes the fluid to change from a liquid to a vapor. Little accurate data is available for sizing valves under such conditions. In these control problems, the instrument engineer must base the selection of valve size on past experiences. Many cases have been solved with excellent results by selecting a valve one size larger than calculated, assuming normal conditions and using a larger pipe downstream than on the upstream side.

From the standpoint of operational economy the pressure drop across a valve must be no greater than that required to maintain a maximum of valve performance with a good control of flow. A valve designed with excessive pressure drop entails use of larger pumps and greater loss in overall efficiency. With this in mind, the Socony Vacuum Oil Company, Inc., Instrument Standards specify certain minimum limitations on valve sizes on pumped liquids. The chart in Fig. 71 gives the minimum valve sizes for a specific rate of flow. For example at a flow of 100 gal. per min. a 2-in. valve is the minimum that may be used. This size was determined to conform with the overall design of the process unit taking into account pumping losses, valve costs, pump costs, etc. This valve size will create sufficient pressure drop to insure good control.

In general, it is evident the process dictates the size of control valve that is to be selected. Although general principles and rules may be followed there is no hard and fast method of determining the valve size. Each installation presents a special problem that must be handled individually.

(This is the fifth installment of Mr. Krieg's discussion of refinery instruments. The next part will be published in an early issue.)

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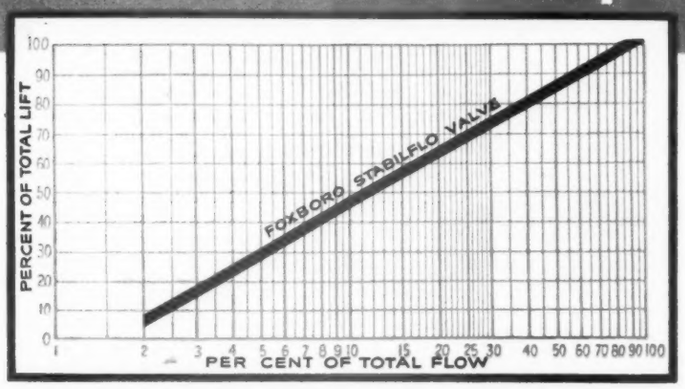

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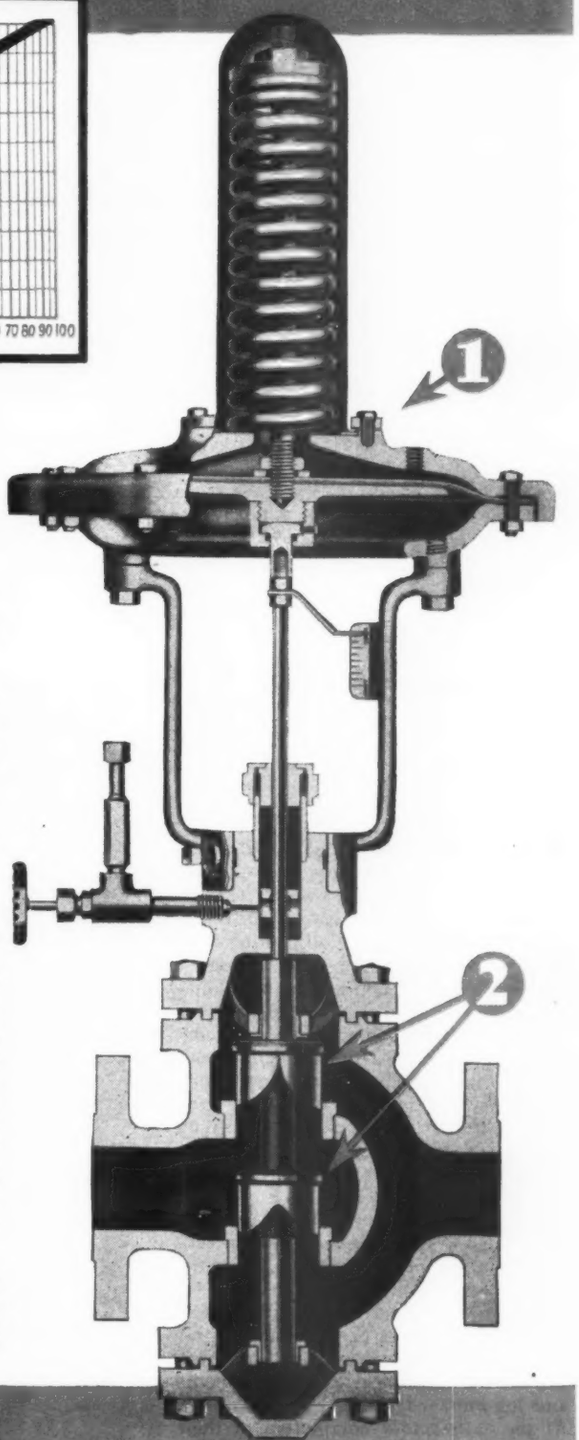
The unique characteristics of the Foxboro Stabilflo Control Valve are graphically revealed in the chart above; . . . *equal increments in controller output (and valve lift) produce equal percentage changes in flow.* Thus under constant pressure drop conditions and on a semi-logarithmic scale, the line plotted is straight.

This achievement was made possible by two major Foxboro developments in valve design. . . .

1 THE INVERTED TYPE MOTOR . . . By reversing the usual position of diaphragm and spring, Foxboro engineers practically eliminate all sources of friction in the action of the motor. Anti-friction bearings are unnecessary. The suspended construction of the valve motor requires no guides. A special flexible coupling between the valve stem and the diaphragm motor allows the stem to establish normal alignment.

This self-aligning motor with its floating action is an exclusive feature of Foxboro Stabilflo Valves.

2 WIDE RANGE V-PORT VALVES . . . This outstanding development corrects the common faults of control valves of conventional types. Almost any kind of port opening can produce equal percentage flow changes within a limited range, but Foxboro's WIDE RANGE V-PORT VALVE extends the limits to the full stroke of the motor. The greater the rangeability possessed by a valve, the greater its ability to handle unusual conditions. Hence, the 50 to 1 rangeability means that the Stabilflo Valve insures satisfactory control at all demands.



Since the success of any control system may depend as much on the performance of the valve as on the control instrument, it will pay you to investigate the advantages of Stabilflo Valves. Write for complete information. **The Foxboro Company, 130 Neponset Ave., Foxboro, Mass., U. S. A.** Branches in principal cities.

FOXBORO
REG. U. S. PAT. OFF.

AUTOMATIC CONTROL VALVES

EXCLUSIVE *Petroleum* **Engineer Picture** *Story*

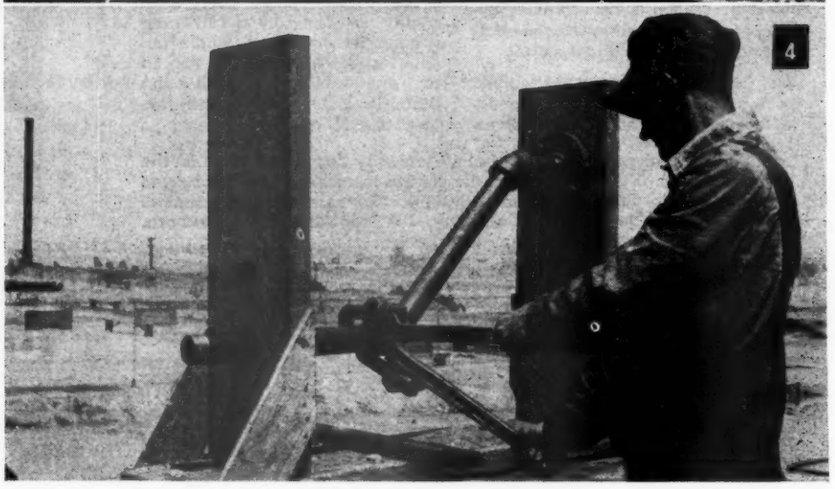
1. ***Sheetmetal***—**A rectangular-to-square elbow ventilator job. The work was judged upon procedure, quality of final product and minimum wastage of stock. Discussional tolerances were 1/16 in. and 1-deg. angle.**
2. ***Machinist***—**Candidate checking completed sleeve for centrifugal pump to meet 0.002-in. tolerance.**
3. ***Electrician***—**Candidate assembling a three-phase motor after trouble shooting and repairing.**
4. ***Pipefitter***—**Assembling 2-in. 45-deg. offset on a jig to meet close dimensional tolerance. Blueprint reading, field sketching, slab layout, hot and cold bending are phases also tested.**

REFINERS TRAINING PROGRAM

JAMES E. HILL
Training and Safety Supervisor
Union Oil Company of Calif.

THE Union Oil Company of California Refineries Management and the Oil Workers International Union (C.I.O.) Locals 128 and 326, began a jointly operated training and qualification program at the Los Angeles and Oleum refineries in 1940. Management and labor select their representatives for a four-man Training and Qualification Committee for each department or plant unit where skills and trade knowledge factors can be sharply delineated. All these committees work through a policy forming Coordinating Committee and generally are supervised by a training coordinator and departmental heads.

A sufficient number of lower job classification workers, depending upon estimated future openings in the journeyman or equivalent No. 1 jobs, are selected upon a seniority basis and placed on a trainee status. They remain on this status at no wage increase and are given preferential practical job assignments and job knowledge and related training. At the satisfactory completion of their training (from two to four years depending upon the job involved) they are recommended by the Training Committee for qualification examination and are examined when requested by management. Candidates who make passing scores are promoted on a seniority basis



takes another step— AHEAD!

among the 2,159,847 in the binders for the 4,037 precincts of Chicago.

Aurora Gasoline Co. To Install Catalytic Cracking Unit

Detroit, March 4—Aurora Gasoline Company of Detroit has signed a license agreement with Universal Oil Products Company of Chicago, for installation and operation of a UOP Improved Fluid Catalytic Cracking Unit with design charge of 4,000 barrels a day. Max. M. Fisher, vice president of Aurora, said installation of this equipment will enable his company to give its customers the best quality gasoline available and increase its supply of domestic heating oil to its expanding markets. He said, this unit represents a major step in the company's expansion.

247,195 Chicagoans

Aurora Gasoline Company of Detroit, Mich. was faced with two important needs:

1. **Production of high octane gasoline to keep ahead of competition.**
2. **A unit that would provide wide flexibility—from maximum quantities high octane gas to distillates—for varied and changing market requirements.**

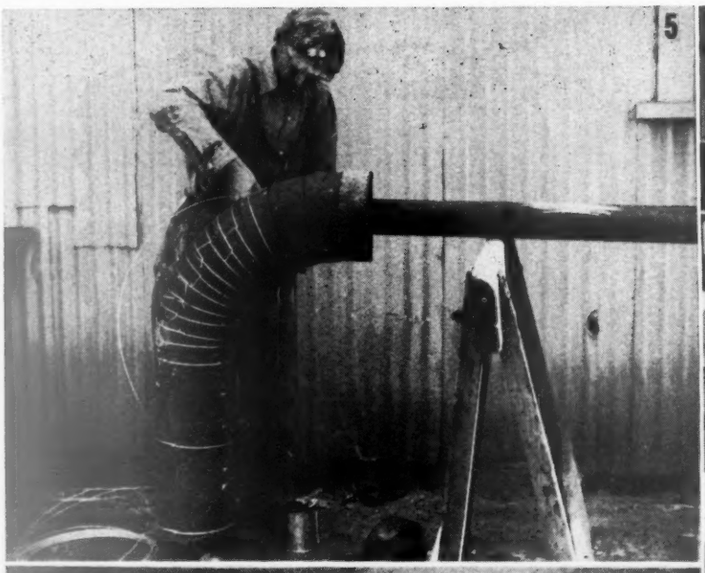
Thorough and exhaustive analysis of the features embodied in the UOP Improved Fluid Catalytic Cracking Unit proved conclusively that this equipment would meet these requirements to the fullest extent. And, in addition, they are assured of a low initial cost and minimum maintenance and operating expense. This new installation will assure Aurora's customers of a gasoline equal in quality to that produced by any refiner.

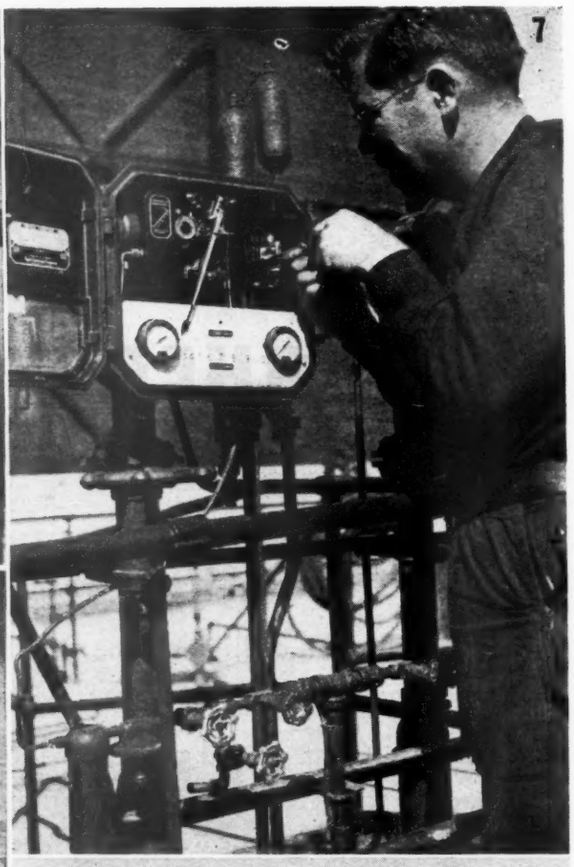
UNIVERSAL OIL PRODUCTS COMPANY

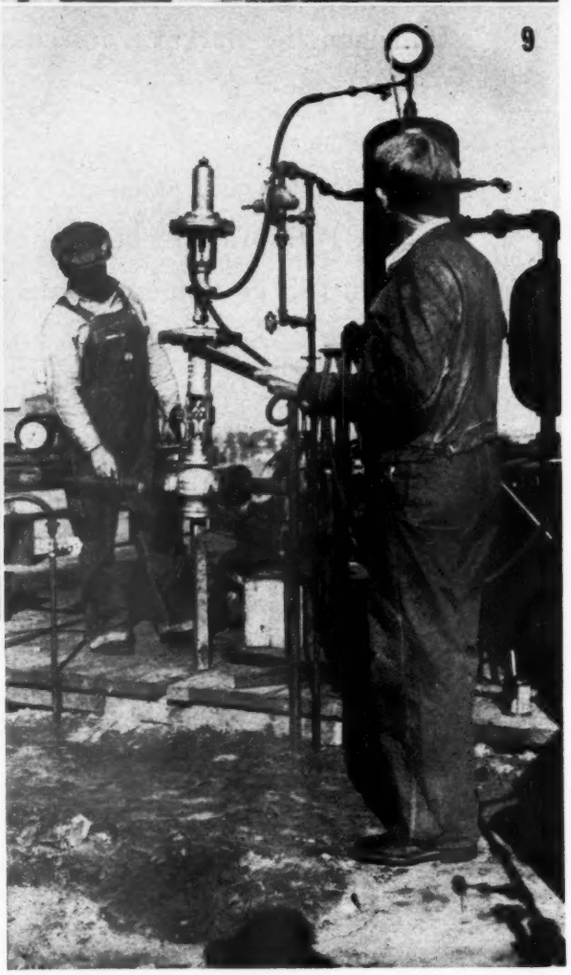
310 S. MICHIGAN AVENUE UOP CHICAGO 4, ILLINOIS, U.S.A.

LABORATORIES: RIVERSIDE, ILLINOIS

UNIVERSAL SERVICE PROTECTS YOUR REFINERY







5. *Insulator*—Installing molded cork pipe covering a 3-in. pipe bend for cold service.
6. *Welder*—Laying out a compound offset spool on the slab working to 1/16-in. and ½-deg. tolerances. Laying out is an important phase of most crafts requirements. Welders are required to weld alloy steels, bronze, cast iron and to meet certain code requirements on carbon steel work.
7. *Instrument Shop*—Troubleshooting a pneumatic transmitter. Instrument shop mechanic requirements are broad, covering pressure, temperature and flow instrumentation.
8. *Boilermaker*—Driving ⅞-in. rivets into a junked still drum. Tests also cover rolling still and interchanger tubes, structural and tank fabrication, etc.
9. *Valve Repairman*—After trouble shooting a pilot operated pressure regulator, the valve is fully overhauled and tested.

WHEN YOU NEED Lap-Joint Stub Ends

Whenever a flanged joint is required, the lap-joint stub end has a great advantage over flanges welded to the pipe. The swivel flange makes it unnecessary to accurately line up the bolt holes before welding; "setting up" is simple and quick because no special clamps or jigs are required to hold the face of the flange absolutely perpendicular to the axis of the pipe. The result is a real saving in time and cost of welding. Field crews report a saving of 25% in erection time for making up a joint using Midwest Lap-Joint Stub Ends in comparison with flanges rigidly fixed to the pipe.

Specify MIDWEST FOR THESE REASONS

FORGED LAP—by special Midwest process that simultaneously upsets pipe and forms lap. Tests prove superiority of process.
LARGE RADIUS FILLET --More metal, hence greater strength, in the critical area of lap where maximum total bending and shearing stresses occur.
HEAVY LAP—After machining front and back, lap is always at least equal to pipe wall thickness.
STRESS RELIEVED—Metal in lap is worked at forging heat, then normalized to assure uniform, close grained structure. Photomicrographs frequently show it to be superior to original pipe metal.
SQUARE CORNER—(instead of a round corner) adds to lap strength and eliminates pockets for accumulation of condensate and sediment which promote corrosion.
MACHINE BEVELED —welding end is accurately machined for easy welding.
PHONOGRAPHIC FINISH—of lap face to hold gasket more securely.
UNIFORM FLANGE BEARING—Back face of lap carefully machined to assure uniform flange bearing necessary to satisfactory joint.
TIME SAVED--In welding and erection because bolt holes need not be carefully lined up before welding.

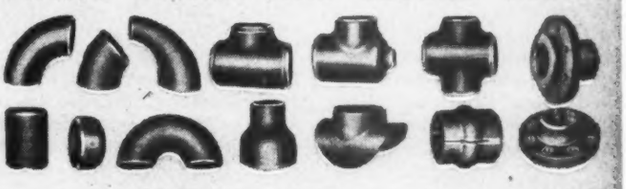
MIDWEST

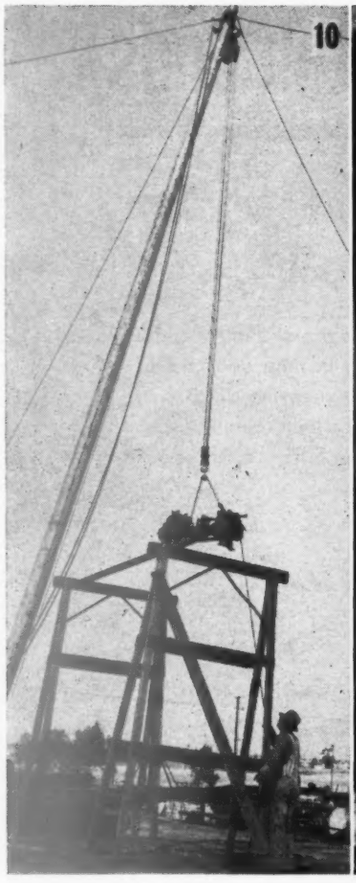
PIPING & SUPPLY COMPANY, INC.

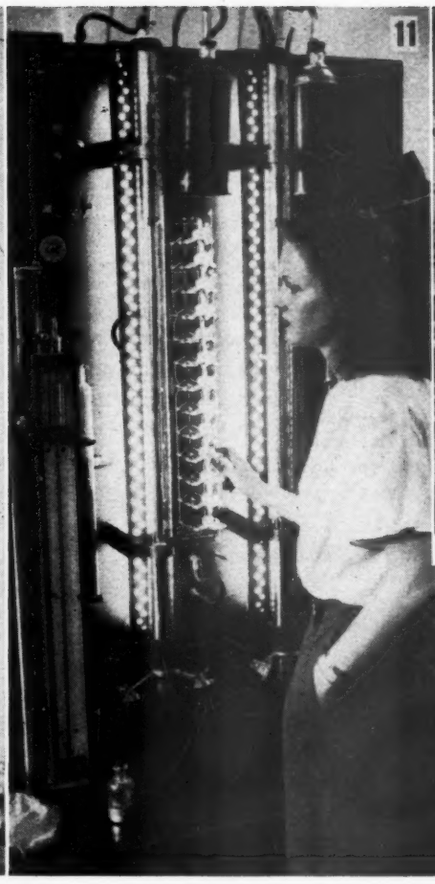
Main Office: 1450 South Second St., St. Louis 4, Mo.

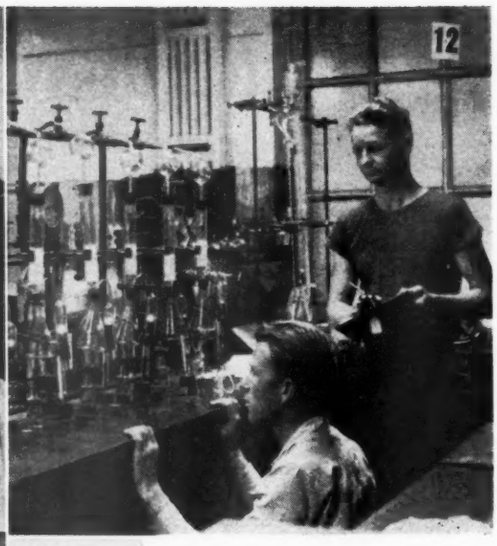
Sales Offices: New York 7—(Eastern Division) 30 Church St., Chicago 3—645 Marquette Bldg. • Los Angeles 33—520 Anderson St. • Houston 2—229 Shell Bldg. • Tulsa 3—533 Mayo Bldg. • Atlanta 3—Red Rock Bldg. • South Boston 27—426 First St. • Distributors in Many Cities

MIDWEST WELDING FITTINGS IMPROVE PIPING DESIGN AND REDUCE COSTS









10. *Rigger*—Trainee lifts a pump over a simulated concrete wall. Rigging requirements are broad, covering all types of light and heavy equipment.
11. *Gas Laboratory*—Candidate operates Podbielniak Hyd-Robot apparatus.
12. *Inspection Laboratory*—Candidate runs ethyl sulphur tests as judge observes operation.

to the higher job classification as openings occur. These tests consist of about two to four hours of written examinations and three to five days of selected performance tests. Objective weighted scoring practically guarantees good agreement between judges' decisions, although all judging is done independently.

The photographs illustrate scenes from typical job tests from various examinations and, in many cases, show how props and jigs are used to simulate field installations.

Training and qualification is under way in crafts, inspection laboratory, clerical and other groups. Basic training for operators has proved very beneficial, although the program for qualification of operators through examination was not started during the war period. To date at the two refineries, 74 tests have been given, involving over 300 candidates. Approximately 88 per cent have passed the tests with an overall score of about 85 per cent.

★ ★ ★

P 753.

HOW TO TEST CYLINDER LUBRICATION

W. F. SCHAPHORST

HERE is a method for determining whether or not a cylinder is properly lubricated, which originated with an engineer friend of mine. He was getting ready to examine a cylinder preparatory to a test on a new lubricant that he was going to try out. This is the plan he adopted:

When the head of the cylinder was removed the walls and head of the piston looked well lubricated and were pronounced by the operating engineer to be in "excellent condition." My friend took four pieces of white paper and asked the engineer to rub them horizontally on the top, sides, and bottom of the cylinder, reaching as far back as possible. These pieces of paper were then marked "Top," "Bottom," "Right Side" and "Left Side" to correspond correctly with actual conditions. They were also dated.

Although this particular cylinder wall or surface seemed to be well lubricated very little oil appeared on the four pieces of paper, and the oil was of a rusty color. After the new lubricant had been in use for three weeks they repeated the operation, and the difference in the two sets of papers was so great that the engineer unhesitatingly remarked that he then had ten times more oil on the cylinder walls than before, notwithstanding the fact that the feed of the lubricator had been cut down to feed one-third as much oil as previously.

Shortly after that my friend had occasion to open another cylinder. This was on a new machine, which had been running but six months, and when the head was taken off the engineer remarked that he could not ask for better lubrication. To my friend the cylinder seemed well lubricated also but he used the paper test and had the engineer himself do the rubbing.

The paper was applied to the top of the cylinder first and to their amazement the paper showed almost no oil at all. The sides were a little better, and there was too much water in the cylinder to make the test on the bottom. They then repeated the test and the papers came out almost entirely free of oil. The engineer remarked that he was glad he had made the test as it convinced him that the cylinder was not being properly lubricated.

This method of testing cylinders for oil deposits is my friend's own manufacture. He admits that it may be crude and probably not the best, but it is simple and has saved the day for him many times. He passes the information on for whatever good it may be to others. If there is a better method of determining when a cylinder is properly lubricated he would be very glad to know about it, and so would I.

★ ★ ★

Avon Fluid Catalytic Cracking Plant Continues Longest Run

By **CLARE K. VILAND***
Tide Water Associated
Oil Company

EXCLUSIVE

THE most spectacular wartime development in the petroleum industry has been the catalytic cracking process. More than two-thirds of the nation's present catalytic cracking capacity is in the giant units engineered and constructed during the war period. Tide Water Associated Oil Company's fluid unit is included in this group.

This plant, in the Avon, California, Refinery, is the world's largest fluid catalytic cracking unit. In aviation service the plant greatly augmented the Avon Refinery's already large production of 100-octane aviation fuel. The Avon Refinery is justly proud of its record in the output of such product, which for the total period of the war years ranked ninth among the 56 United States manufacturers of finished 100-octane gasoline.

C. K. Viland

The huge fluid catalyst unit was constructed in record time and was placed on stream December 29, 1944, and was ready for normal operation shortly thereafter. Ground was first broken on February 3, 1944, the actual construction time being only 10½ months. The Avon catalytic cracker, together with 4 supplemental units built at that time, all of which contributed to the war effort, was erected by C. F. Braun and Company of Alhambra with a construction crew that never exceeded 500 men and dropped to 350 toward the end.

Modern field equipment, including two large 200-ton guy derricks, was used in erecting the catalytic cracking plant. Among the features of improvements over previous units embodied in the Avon plant are curved knuckle joints in the large vessels, improved methods of applying alloy protection, new type regenerator insulation, trunnion-type duct supports, dampers on Cottrell precipitator, and a steam eductor in the stack, which together allow inspection and repairs on the precipitator without shutdown, mechanical ventilation of all buildings, and air-conditioning of the control house.

During the Avon catalytic cracker's first aviation run, operations were conducted at or near design rating for charging 16,000 bbl. a day of gas oil while cracking under severe aviation operating conditions. Wartime requirements made it necessary to conduct operations so that maximum quantities of isobutane and light olefinic hydrocarbons for use as alkylation feed stocks were the main products, for alkylate, a synthesized organic chemical comprised largely of isooctane, was the most important single ingredient of 100-octane aviation gasoline. Under the intense cracking conditions employed, the Avon catalytic cracking plant was producing nearly twice as much light hydrocarbons for conversion to alkylate as gasoline for aviation base stock. Aerocat synthetic catalyst, manufactured by the American Cyanamid and Chemical Corporation, was used to achieve the desired results during the manufacture of aviation gasoline.

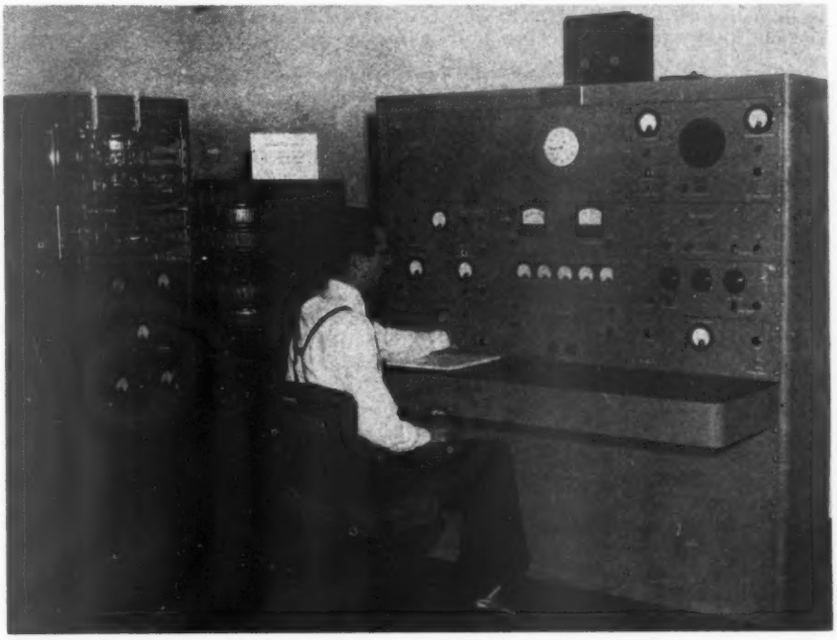
● **Motor fuel manufacture.** Immediately following V-J Day last August the fluid catalytic cracking plant of Tide Water Associated Oil Company was converted from aviation operation to the manufacture of high octane motor fuel.

In changing over to motor fuel operation it was not necessary to shut the fluid unit down, but instead, charging rates were actually increased to permit the production of a greater volume of gasoline substantially as high in octane rating as that produced and utilized for aviation base stock during the war.

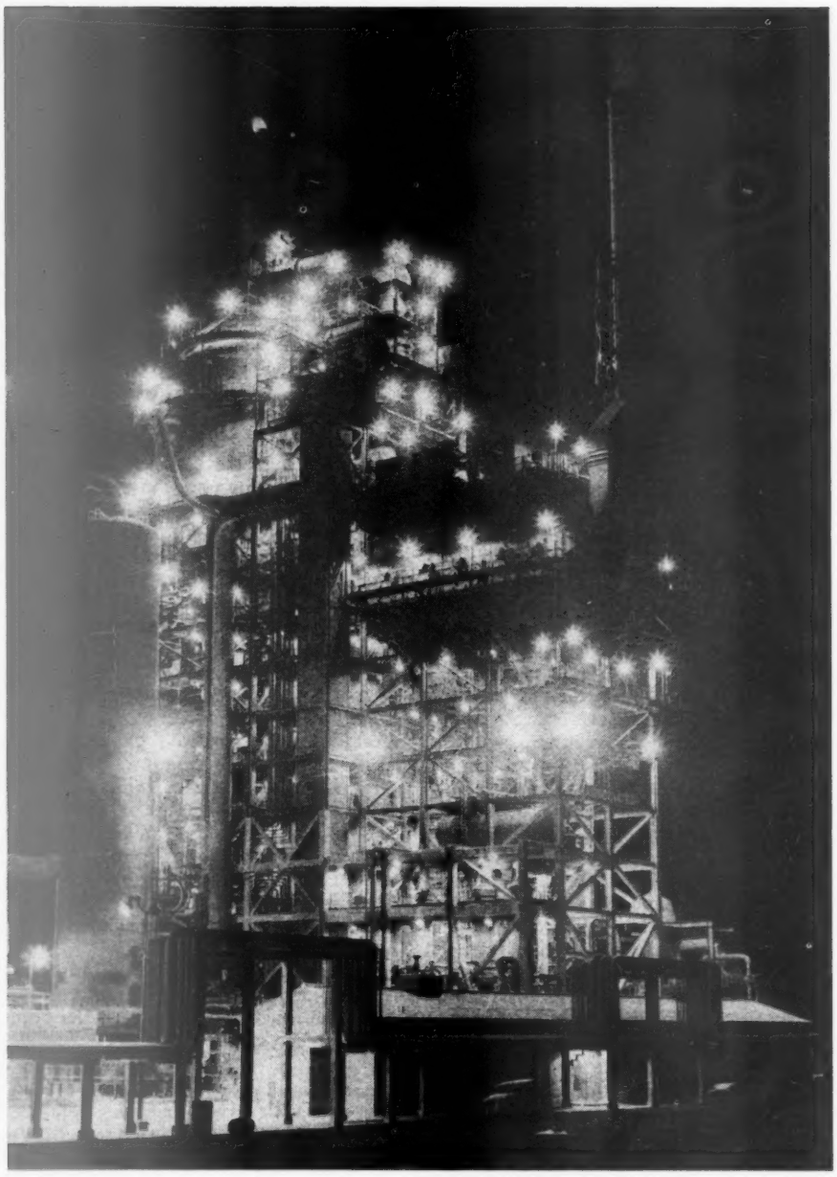
In cracking heavy gas oils to motor fuel, processing is generally similar to aviation operation and is briefly described as follows:

Oil feed is charged as a liquid into the reactor riser. Hot powdered catalyst from the regenerator enters at the point

One of the adjuncts of modern refining practice used at Avon is the mass spectrometer, which in remarkably short time and with great accuracy analyzes complex mixtures of hydrocarbon gases. Important refining processes in the huge Tide Water Associated plant require control as provided by this instrument.



*Clare K. Viland began with Tide Water Associated Oil Company on June 4, 1929, as a chemist at the company's Watson (California) Refinery. He was transferred to the Research and Development Department of Tide Water Associated's Avon (California) Refinery on March 6, 1936, and on May 6, 1942, became supervisor of that department. In that capacity he had supervision of engineering and technical work, including new units, new processes, test runs, economic studies, etc. During that period he was also engaged in development work in connection with the erection of the fluid catalytic cracking plant at Tide Water Associated's Avon Refinery. On March 16, 1946, Viland was advanced to the position of general supervisor of research and development for the Associated Division of Tide Water Associated Oil Company, in charge of all research and development work of the entire division.



Built in record time for Tide Water Associated Oil Company, the Avon, California, fluid catalytic cracking unit is said to be the largest in the world.

of oil injection, supplies process heat requirements, and through vaporization transports the catalyst upward into the reactor. Cracked oil vapors leave the reactor through a cyclone separator and enter the fractionating system where gasoline, gas, and cycle oils are separated. Spent catalyst is withdrawn continuously from the reactor at a rate controlled to hold the desired level in the reactor. Air from the turbo-blower moves the catalyst upward into the regenerator, where carbon is burned off. Combustion gases containing entrained catalyst pass in sucession through a cyclone separator, a waste heat boiler, and a Cottrell electrical precipitator. Regenerated catalyst flows into the reactor riser at a rate controlled to maintain a constant reactor temperature.

In the transition from aviation to motor fuel operation the synthetic catalyst in the unit is gradually being replaced with Filtrol catalyst, which is presently being added to maintain operating levels. This catalyst is manufactured in California and is particularly suited to Avon's requirement in manufacturing high quality motor fuels.

With the passing of the wartime necessity to produce maximum 100-octane aviation gasoline, charging rates have been increased to as high as 24,000 bbl. a day, and simultaneously the feed stock has been made heavier and cracking severity reduced somewhat as compared with wartime operations. For production of motor fuel it has been found desirable to adjust conditions so that only about 50 per cent of the feed stock is converted into gasoline and lighter fractions. Under present conditions the yield of motor fuel is greater with respect to the yield of light gaseous hydrocarbons and coke so that higher overall liquid yields of gasoline and burning oil fractions are obtained.

Most of the catalytic gasoline, together with other high octane components such as produced through alkylation of the catalytic cracker's isobutane, butylene, and propylene production, and through superfractionation and solvent refining of straight run gasoline stocks, is used in the manufacture of new postwar premium gasoline. The new gasoline has the highest octane number and best road performance of any gasoline that the Avon Refinery has ever made available to the motoring public. The consumer response to this new type of fuel has been so overwhelming that well over 50 per cent of the refinery's output is this premium grade of motor gasoline. A similar experience has generally been true for companies on the Pacific Coast who operate equipment formerly used for manufacture of 100-octane gasoline. In most cases only the higher cost or marginal aviation gasoline components have been eliminated from motor fuel manufacturing schedules.

● **Turnarounds and on-stream efficiency.** To date the total calendar day on-stream efficiency of the Avon fluid catalytic cracking unit is approximately 89 per cent. The unit has been off stream for only one turnaround, which consumed 22 days between "oil out" and "oil in"; however, mechanical work was completed in 18 days time, 4 days being lost because of unavailability of a damaged blower part. Repair work on the turnaround required slightly over 41,000 man-hours on the catalytic cracking unit and slightly under 6000 man-hours on the gas plant. The mechanical condition of the unit was found excellent when inspected after its first operating period totaling 154 days, including 145 days of continuous operation, and subsequent runs will unquestionably be of much longer duration.

Other off-stream time includes one occasion for repairing a leaking waste-heat boiler; one occasion to replace natural catalyst with synthetic in order to allow more severe cracking conditions during the war; one occasion to repair a faulty speed governor on the main blower, and one occasion shortly thereafter to remove this same speed governor.

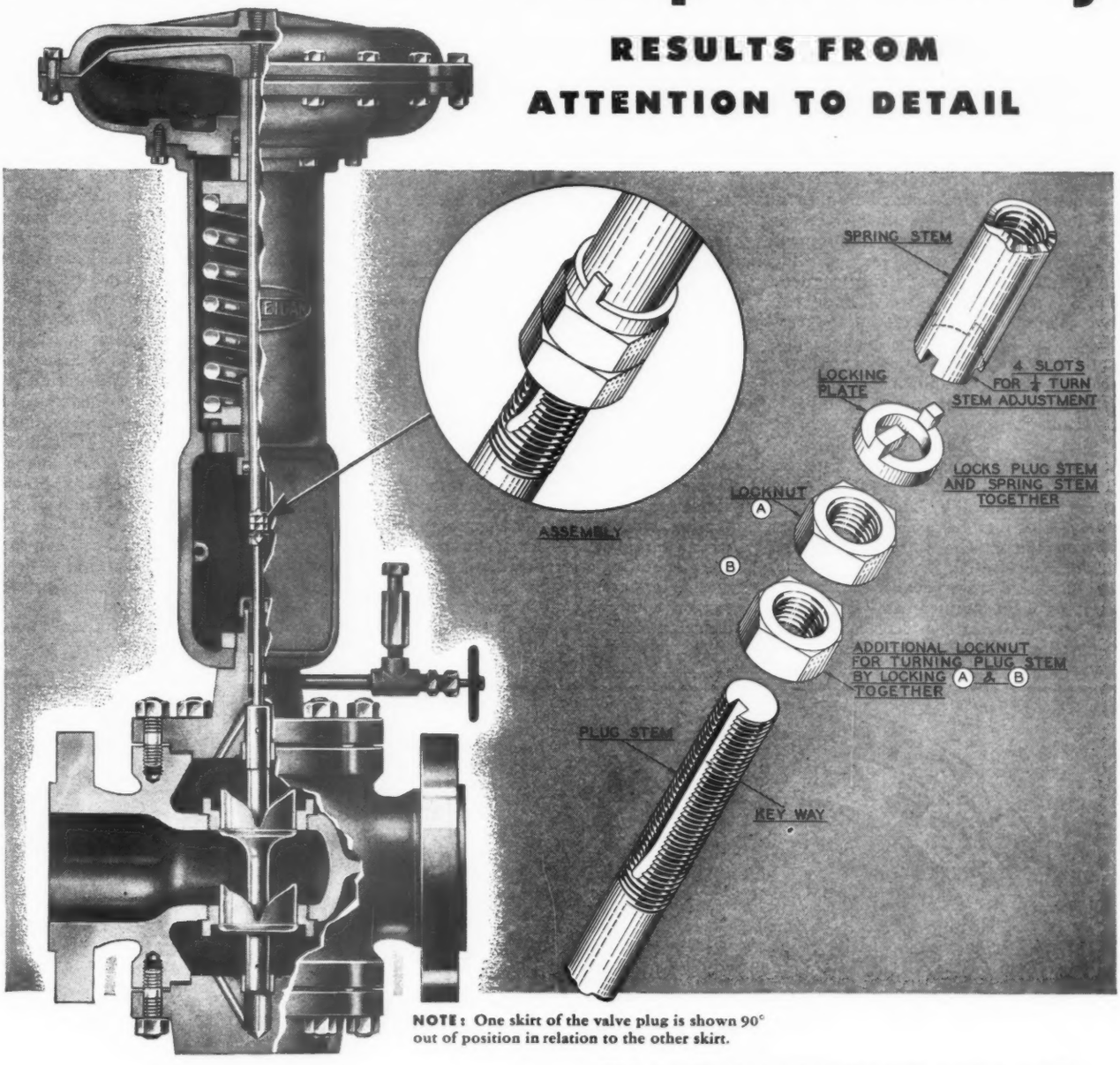
The Avon unit at the time of this writing is still operating on its longest run. It has been on stream since before the war's end and has already operated in excess of 250 days since the current run was begun on July 12, 1945. The current run has included both aviation and motor fuel operation, demonstrating the flexibility of the fluid catalytic cracking process.

It is anticipated that after the first 2 or 3 turnarounds, during which minor changes are usually expected, the normal length of runs will be increased to a period of approximately 9 months to one year.

● **Control of product quality.** Several interesting new methods of checking product qualities are in use at Avon.

Control Valve Dependability

RESULTS FROM ATTENTION TO DETAIL



NOTE: One skirt of the valve plug is shown 90° out of position in relation to the other skirt.

New Mason-Neilan Design Provides Positive Lock Between Plug Stem and Spring Stem

Under conditions of high fluid velocities, a valve plug may tend to rotate or spin. This condition is not detrimental if the mechanical construction is sufficiently rugged to counteract the torque generated. In other words the plug, plug stem, spring stem and diaphragm button must be locked together as a unit.

In the conventional plug-spring stem assembly, the plug stem locknuts are the only non-positive fastener. Locknuts can be a source of trouble on large valves because their holding power depends on mechanical tightness.

With the Plug-Spring Stem Key Lock, standard on all valves sized 4" and above, the torsional strain is entirely removed from the locknuts and placed on the two lugs of the locking plate. This is accomplished by means of four slots milled in the end of the spring stem which receive two equally spaced lugs on the locking plate. The locknuts simply hold the locking plate in position. A keyway in the plug stem engages one lug on the locking plate and completes the lock. The four mating slots in the spring stem provide for the adjustment of the plug position by quarter turns of the plug stem.

By actual test, this new Mason-Neilan assembly withstands torsional stress to the point of stem failure. The resistance is three to four times that of tightly set locknuts in the locking direction, and many times the resistance in the counter-clockwise direction.

MASON-NEILAN REGULATOR COMPANY, 1187 ADAMS STREET, BOSTON 24, MASSACHUSETTS

New York • Philadelphia • Pittsburgh • Cleveland
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MASONEILAN

Houston • Los Angeles • San Francisco
Mason Regulator Co. of Canada, Ltd., Montreal, Canada

One of the new war-developed instruments used is the mass spectrometer. By means of this apparatus it is possible to rapidly analyze the products of the cracking reaction and thereby keep the catalytic-cracking and gas-recovery stabilizer units operating at maximum efficiency.

The mass spectrometer, formerly used only as a research tool, is now a practical industrial instrument. Only a minute quantity of gas or vaporized liquid is required for the actual determination of components present. The instrument operates on the principle of subjecting the sample to electron bombardment in an ionization chamber, which converts some of the neutral molecules into positive ions. These are sorted out according to their mass by electric and magnetic fields in an analyzer tube and their relative abundance recorded. From the mass spectrum of the mixture, photographically recorded, and a knowledge of the mass spectra of its components, the composition of the mixture can be quickly determined.

One room of the control building of the catalytic cracking plant is fitted as a laboratory. Efficient operating practices are assured by making frequent analyses of flue gases so that optimum oxygen utilization can be maintained during regeneration of the catalyst. Also, by making carbon determinations on samples of regenerated catalyst at regular 2-hr. intervals complete catalyst regeneration is always effected and predetermined catalytic cracking severities maintained. Other tests commonly used to guide operations are made by this laboratory, the main refinery control laboratory, or by the research and development department.

● **Chemical cleaning of heat exchangers.** An operating technique that may prove of substantial value to the industry has been developed at Avon. This is a new *in situ* method of cleaning slurry to feed exchangers, which greatly reduces the time required for this operation.

In the Avon unit, as in many others, the gas oil feed is heated by means of heat exchange against fractionator bottoms. These exchangers formerly became dirty very fast on the feed side. After about 10 days time the coefficient of heat transfer had usually dropped from about 40 to 15 B.t.u. per hr. per sq. ft. per degree Fahrenheit mean temperature difference. This resulted in a drop in feed preheat temperature of 5°F. per day from its normal level of 400°F. and necessitated the mechanical cleaning of one exchanger each week. The fouling material was found to be a hard resinous material of acidic nature that forms on the outside of the tubes. The fouling tendency is more pronounced when charging gas oil from storage than when operating on freshly distilled stock and is apparently due to reaction of oxygen with compounds present in the charging stock.

The following procedure for cleaning feed heat exchangers has now been used at Avon for nearly a year:

The exchanger to be cleaned is bypassed and drained. A refinery truck equipped with a 2000-gal. tank containing 5° Baume caustic soda is backed under the exchanger. A centrifugal pump takes suction from the tank and circulates caustic at the rate of about 350 gal. per min. through the exchanger and back into the tank. During the circulation period of about 12 hr. steam is introduced into the tube side of the exchanger, maintaining the caustic temperature at about 175°F. After this treatment hot water is circulated through the exchanger for about 5 hr., after which the exchanger is washed with water for 1 to 2 hr. Inspection of the exchangers after such chemical cleansing has shown them to be cleaner than after mechanically removing the deposit. This cleaning treatment has proved so successful at Avon that a permanent cleaning installation is being incorporated as an integral part of the exchanger installation.

From all points of view the Avon unit has given a satisfactory performance. Many representatives of other companies have visited this fluid catalyst plant, which is considered a model unit of its type.

It took teamwork to build and run the new plant, and all who played a part in its development and construction are proud of its record. Its products greatly helped the war effort and will now make for better peacetime living. ★★★

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

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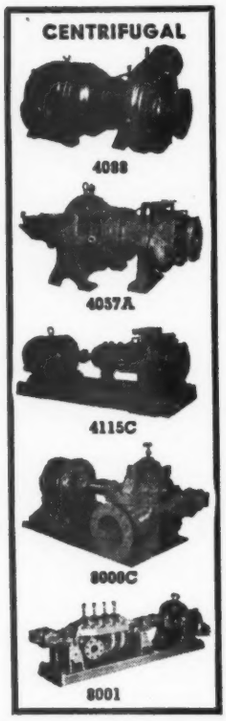
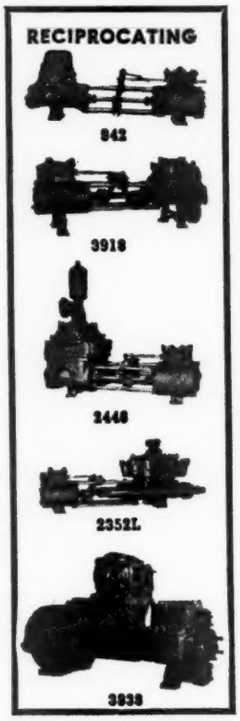
PUMPS

BUILDERS OF OUTSTANDING PUMPS SINCE 1869





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COMPRESSION BY ROTARY SQUEEZING

By **JOHN W. CROCKER,*** Elliott Company

EXCLUSIVE

Positive displacement rotary compressor, designed as marine gas turbine, has application in many fields.

AIR compression machinery, as we know it today, made its first appearance as a logical outgrowth of the invention of James Watt's reciprocating steam engine. With the early steam engine as a prime mover, the reciprocating compressor established its own limited field of application, and as more exacting conditions arose, new types of compression machinery were developed to satisfy industrial requirements.

The slow speeds, weight, and space limitations of the original reciprocating compressor were overcome by the development of the centrifugal machine, which lacked the stability of performance of its predecessor. It must be observed, however, that this form of compression machinery had taken a step toward higher rotation for the driving engine.

John W. Crocker

Modifications of the basic types of compression machinery such as the sliding vane type reached the market with varying success. Although possessing many advantages in its thermodynamic cycle, this unit falls short mechanically because of the need for lubrication of vanes within the air chamber. Another type of compressor of a modified sliding vane type using a liquid piston has its assets, but must, of necessity, have liquid in contact with the air during the compression cycle.

Various gear type units find limitations of capacity an insurmountable problem.

Into this field, already covered by so many diversified types of compressors, is introduced the Elliott-Lysholm as a distinctly new approach to the problem. Ideal compression is the objective of every compressor designer, and the Elliott-Lysholm makes a substantial stride toward this goal. Though being specifically developed to permit the marine gas turbine to take a place along with diesel and steam power, it has applications in many other fields.

● **The Elliott-Lysholm.** The Elliott-Lysholm is a positive displacement rotary compressor that, by virtue of its freedom from rubbing surfaces, its high rotating speed, and its internal compression before discharge, achieves high efficiency and a wide range of stability.

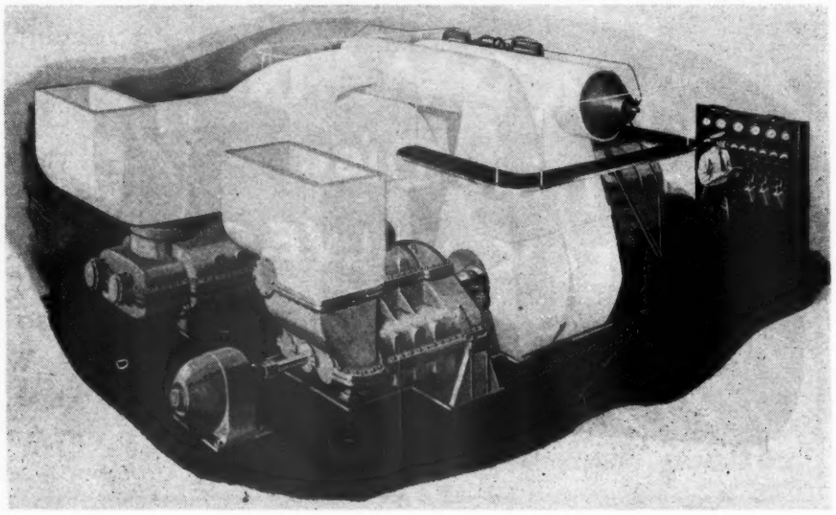
The marine gas turbine constituted the first important application for the Elliott-Lysholm (See Fig. 1). Some of the striking advantages obtainable with this power plant are high efficiency characteristics at low loads combined with the rapidity with which full load conditions can be achieved. Compressor performance is a determining factor in the procurement of these features.

The refinery field holds diversified applications for compression machinery. The tremendous volumes of air used in the cracking processes dictate a need for the highest possible efficiencies. Governed volume requirements would presuppose an advantage in positive displacement. In the catalyst-regeneration process where the catalyst is being revived so that it can be returned to "active duty," any oil in the air or oxygen line would be highly detrimental, and should be avoided. A range of pressures by a single unit would in itself appear highly advantageous, but if this range can be obtained without great drops in efficiency, the millenium of air compression seems near. Though no single, modern compressor can match all the refinery industry's needs, this helical gear type holds great promise.

● **Design.** From Fig. 2 a basic conception of the construction used on a 10,000 c.f.m. compressor can be studied. The male and female rotors are supported in bearings at both ends. The lubricating oil is kept from the inlet air, and the hot high-pressure air is separated from the gear box oil by a combination of radial and axial seals. The rotors are accurately timed by gears to permit the maintenance of close running clearances between mating surfaces of the lobes during rotation. Axial location of the rotors is achieved by Kingsbury floating shoe type thrust bearings. The casing is jacketed in such a way as to permit expansions of this casing to approximate very closely the dimensional changes occurring in the rotors themselves. The drive is shown in Fig. 2 at the inlet end of the male rotor. This location is not paramount, for flexibility both of speed and location can be achieved to meet current needs.

The previously mentioned features were based on fundamental design specifications. A compressor was required to deliver a metered flow of air, at the

FIG. 1.



*John W. Crocker was educated in Edinburgh, Scotland. Graduated in mechanical engineering from Heriot-Watt College of Edinburgh University. Worked in Britain and U. S. for 10 years on manufacture and design of paper making machines and subsidiary mill plant, until joining the Elliott organization in April, 1942. With Elliott Company, has been associated almost continuously with design and development of the Elliott-Lysholm compressor as it pertains to gas turbines, superchargers, and industrial applications. Is a member of the American Society of Mechanical Engineers.

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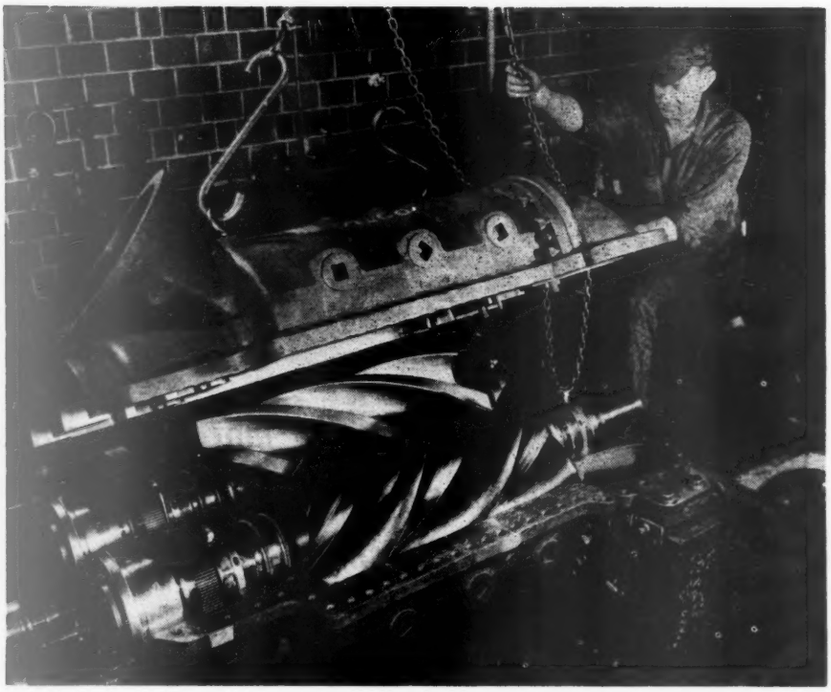


FIG. 2.

highest possible efficiency, whose peak performance could be maintained over a wide range of speed and pressure ratio. The unit must incorporate a compactness of design to match the most competitive units, with high rotating speeds associated with modern drivers.

● **Detailed construction.** Some salient features in mechanical design are evidenced in the casings, rotors, seals, bearings, and gear construction.

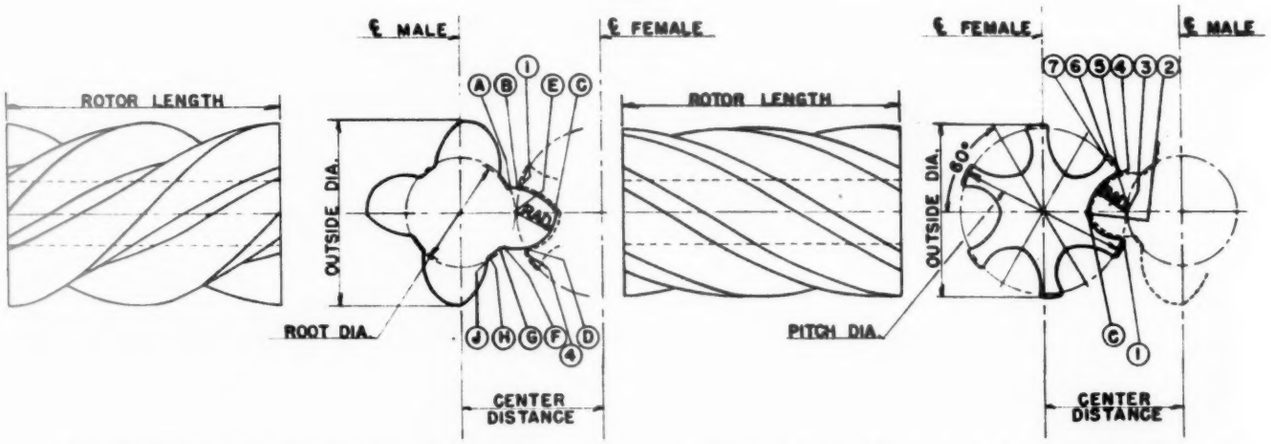
The casings are meehanite castings, split horizontally over the entire length of the machine and vertically at the inlet end of the rotor casing. Jacketing is achieved by a double wall construction. By carefully designed baffles, a temperature gradient approximating rotor conditions is achieved over the casing length and bores. Judicious ribbing permits a rigid, yet light construction. During manufacture, frequent heat treatments are given these casings between machining operations to eliminate any pent-up stresses that could conceivably cause distortion in such complicated castings. It is interesting to note that both inlet and discharge ports are incorporated in the main castings.

Rotors are cast meehanite, with steel stub shafts securely silver-soldered in each end. Tests have shown that the meehanite breaks away before release of this silver-soldered joint. In order to assure accurate clearances, as these rotors mate together, the rotor shafts have ground surfaces, the profiles being cut relative to these diameters. This construction of rotor, although not the optimum from the weight standpoint, still permits a hollow, rigid construction relatively cheap to manufacture.

By combining a radial and an axial seal with an intermediate vent, perfect sealing of oil from the air chamber is possible. The shaft surfaces under the radial seals are hardened by spray coating before grinding. Axial seals are silver carbon, nose type, rubbing on hardened steel, lapped mating rings producing a positive seal.

Thin shell, steel-backed, babbitt bearings are supported in heavy steel housings to form the main bearings. The shafts have hardened, ground bearing sleeves, permitting close clearances with 360 deg. contact precision bearings. Lubrication and cooling of the bearings is achieved by insertion of high pressure (60 to 90 lb. per sq. in.) oil to a central groove, with axial flow in both directions over the bearing surface. This oil is then deflected by slingers around the housing, which is shielded, thus permitting an equalization of housing, bearing, and shaft temperatures. Bearing loads are in the vicinity of 600 lb. per sq. in., a figure far in excess of general turbine

FIG. 3.



CONSTRUCTION OF PROFILE ON MALE ROTOR

Curve "AC" is an epicycloid, generated by point "1" on female pitch circle, passing through point "C" as pitch circles roll together.

Curve "CD" is a true arc with radius "E"—center on pitch circle.

Curve "DF" is an epicycloid, generated by point "4" on female pitch circle, passing through point "D" as pitch circles roll together.

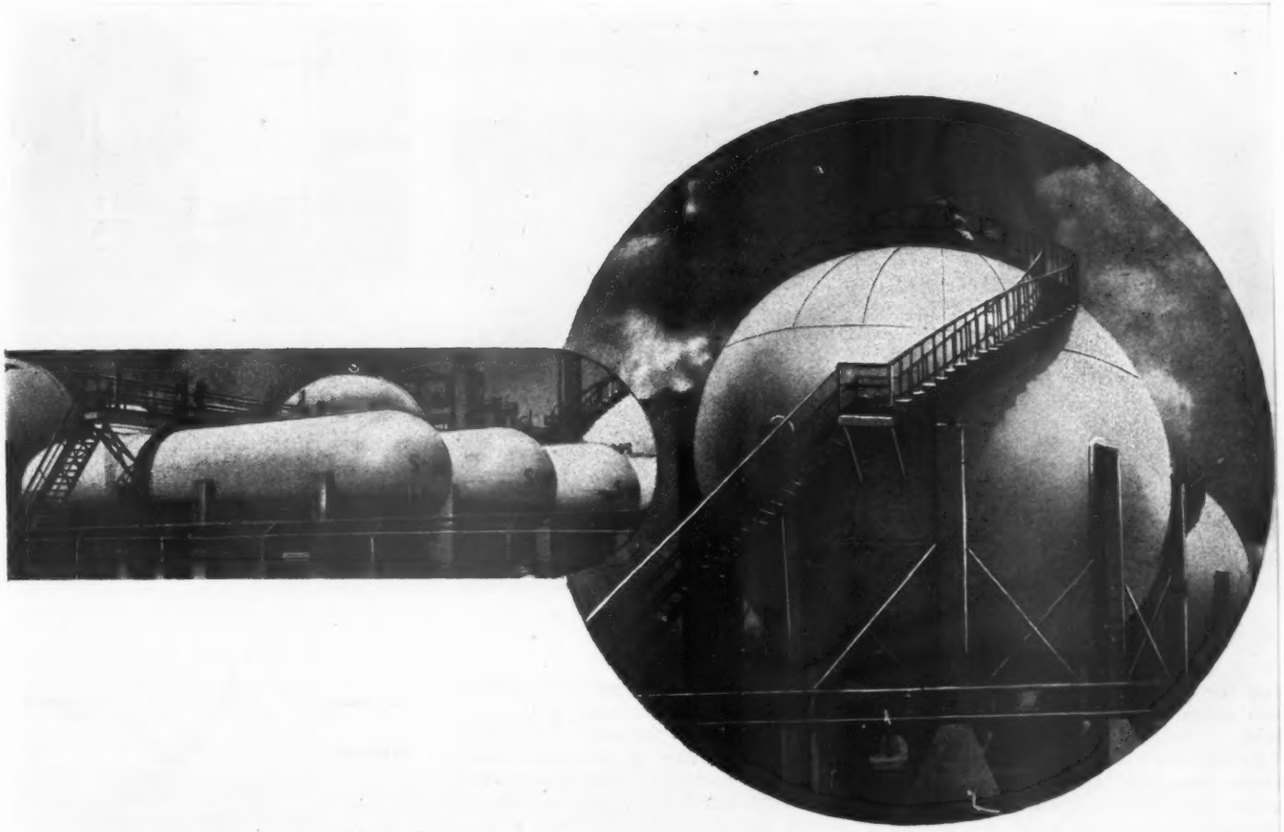
"F-G-H-J" form the dedendum of the male rotor.

CONSTRUCTION OF PROFILE ON FEMALE ROTOR

Curve "1-2" is a superior epitrochoid, generated by point "C" at tip of male rotor, passing through point "1" as pitch circles roll together.

Curve "2-4" is a true arc with radius "3"—center on pitch circle.

"4-5-6-7" form the addendum of the female rotor.



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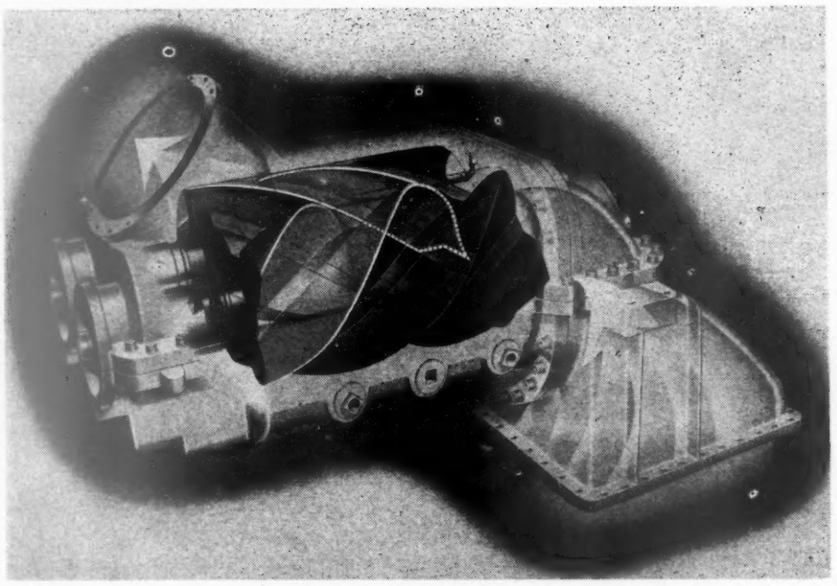
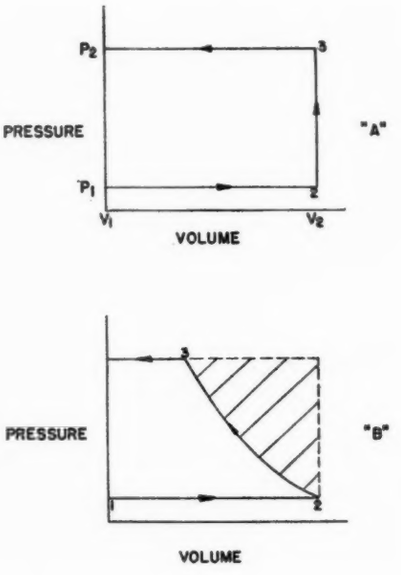


FIG. 4.



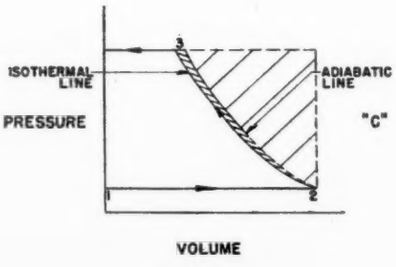


FIG. 5.

practice. This bearing loading is, however, common practice in the automotive field.

In order to achieve the accurate clearances demanded of this unit, timing gears must be in accord with high speed practice. By tapping aircraft practice of hardened ground teeth, it was possible to maintain narrow face width and quiet operation. Timing is performed by the insertion of tapered dowels between a hub secured to the rotor shaft and the gear ring. This operation is performed in a rig especially designed for rotor timing, so that bearing clearances are not a factor causing error. These gears are lubricated by means of a thin film oil spray, directed at the unmeshing of the gears during rotation.

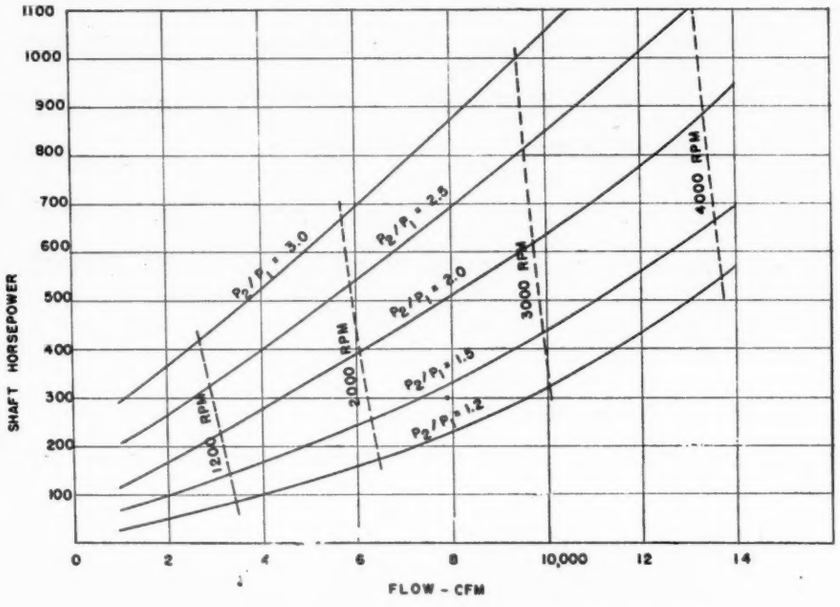
An effort has been made to synthesize this design so that parts are balanced by weight and proportion, consistent with high speed practice.

● **Seal line.** The basic rotor configuration is outlined by Fig. 3. The helical surfaces that follow the basic profiles form the fundamental difference between the Elliott-Lysholm and other types of compressors. From Fig. 4, a visual aid to the seal line formation by the interaction of these profiles at the rotor bores is produced. This seal line is formed by a close clearance between mating surfaces, and results in a separation of the succeeding charges of air. The clearance at the seal line is of a predetermined magnitude by design, and is consistent throughout rotation of the rotors. An understanding of this seal line permits a ready appreciation of the plunger effect achieved in this rotary machine, in an axial direction during rotation.

● **Suction and ramming.** As any pair of lobes are rotated and unmeshed into the lower half of the inlet end of the machine, they create behind them a suction space that increases circumferentially and axially as rotation proceeds. This corresponds to the suction stroke of a reciprocating compressor and is completed by the passage of the succeeding lobe over the edge of the inlet port. This porting is primarily axial, and is constructed so that it communicates with the lobe spaces so long as suction continues. There follows a complete enclosure of two charges of air between the casing bores and the end walls, and the boundaries of the male and female rotor lobe profiles. The volume of these charges is a per lobe displacement. The total displacement of a unit per revolution of the male rotor is roughly equal to the annulus between the male rotor outside diameter and the root diameter.

By reference to Fig. 8, which represents actual test curves for a 10,000 c.f.m. compressor, volumetric efficiencies in excess of 100 per cent have been obtained. Volumetric efficiency has been defined as the actual inlet flow, divided by the displacement of the compressor. The phenomenon that is responsible for this amazing result we have termed "in-

FIG. 6. 10.000 c.f.m. ROTARY COMPRESSOR.
SHAFT HORSEPOWER vs. FLOW



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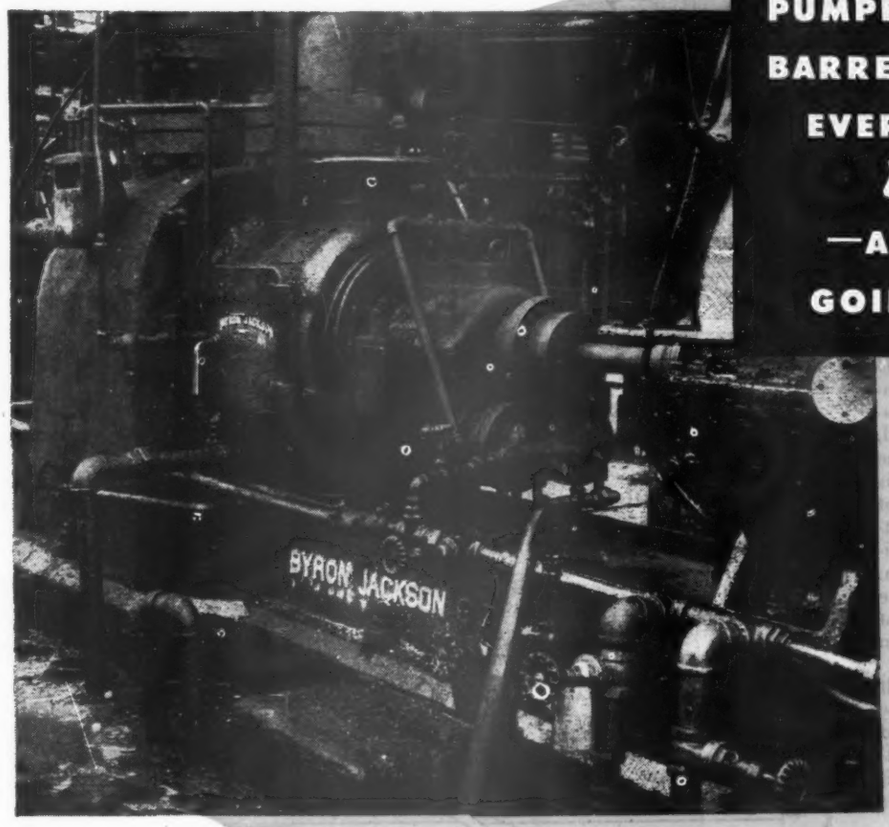

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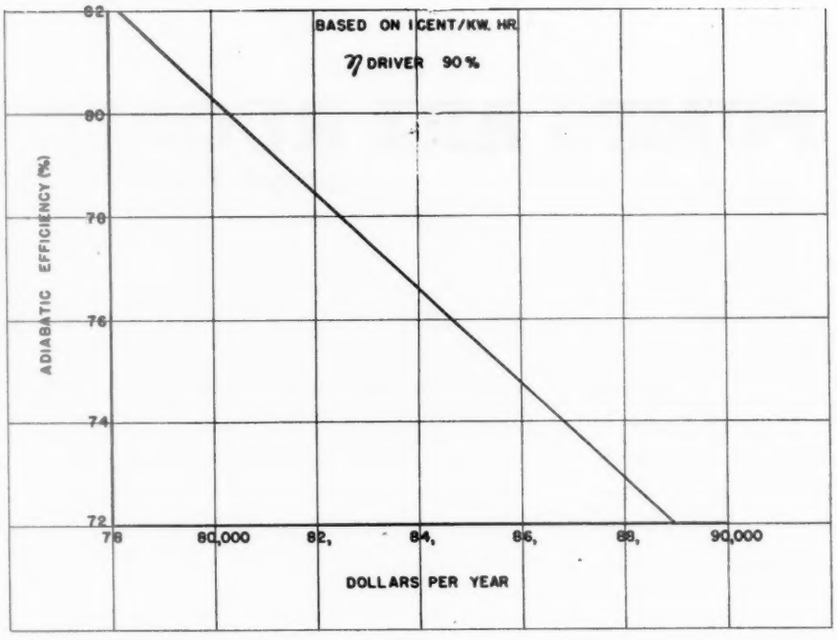


FIG. 7. OPERATING COST-EFFICIENCY.

let ramming". This is a governable factor controlled by inlet port design.

In the suction process, inlet air is inhaled by the progessively enlarging spaces between the rotors. When displacement volume is attained, the inlet port could conceivably cut off the charge; but, due to the high axial velocity of the incoming air an inertia "supercharging" occurs, starting at the extremity of the inlet chamber. Because of the rotor's high rate of rotation, an advance of the port closing is permissible, proportional to the period required for the pressure wave to traverse the rotor length toward the inlet end of the casing. During this period, inlet flow continues and a full volume of air at higher than inlet pressure is entrapped. This ramming is dependent on the high rotating speed of the Elliott-Lysholm compressor, and the axial direction of flow, inherent in its design. This is demonstrated by Fig. 8 on the 1200 r.p.m. curve where ramming is not apparent and a distinct droop occurs on the curve.

High volumetric efficiency is in itself of academic interest, but the added flow for the same power can be translated to higher adiabatic compressor efficiency. This, in turn, means accumulated cost reduction, which is no longer mere academic interest.

● **Built-in compression.** As rotation proceeds, the entrapped volumes of air in the two mating spaces experience a volume reduction and immediately thereafter are united into one chamber. This volume reduction continues with the charge isolated from the preceding and succeeding charges, until a predetermined pressure is reached, when the discharge port opens. Pressure ratio corresponding to the discharge port opening has been termed "built-in compression." The magnitude of built-in compression to be designed into the machine is determined by the discharge pressure conditions, and the range over which the unit operates. Exact positioning of peak performance for adiabatic compressor efficiency is governed, for any one speed, by the degree of built-in compression. Therefore, the designer has control of best possible operating efficiency for any desired speed and pressure range.

The effect of built-in compression on power requirements for compression can best be illustrated by an indicator or pressure volume diagram. "A," Fig. 5, shows a square card, resulting from a cycle without internal compression. Inlet air in this case is exhausted directly against discharge pressure conditions, with the corresponding work losses. Considering adiabatic internal compression similar to the Elliott-Lysholm cycle, a card similar to "B" Fig. 5, is obtained. This shows a power sav-

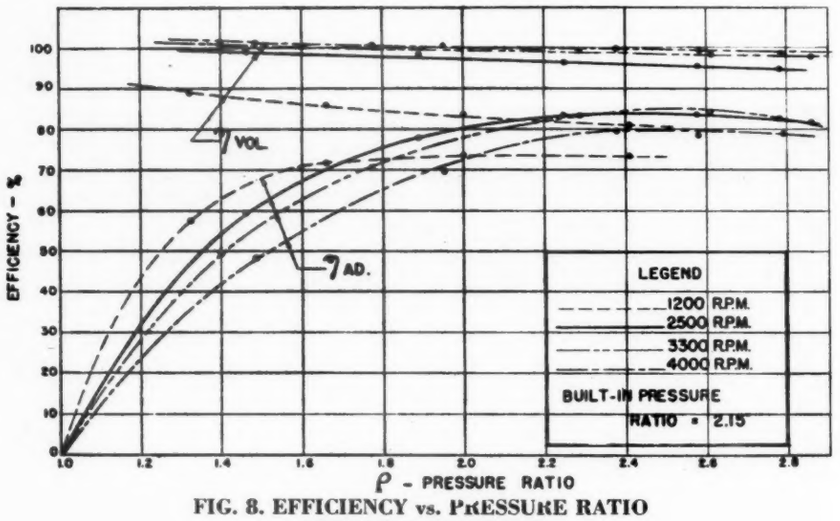
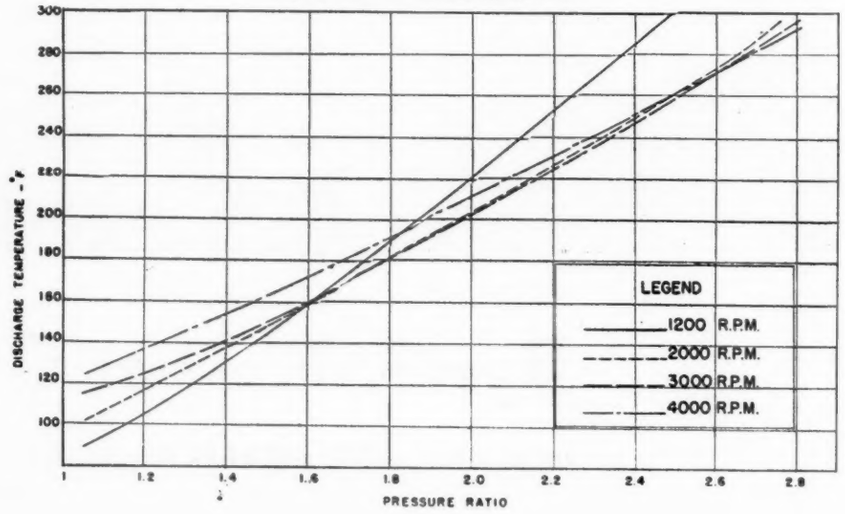
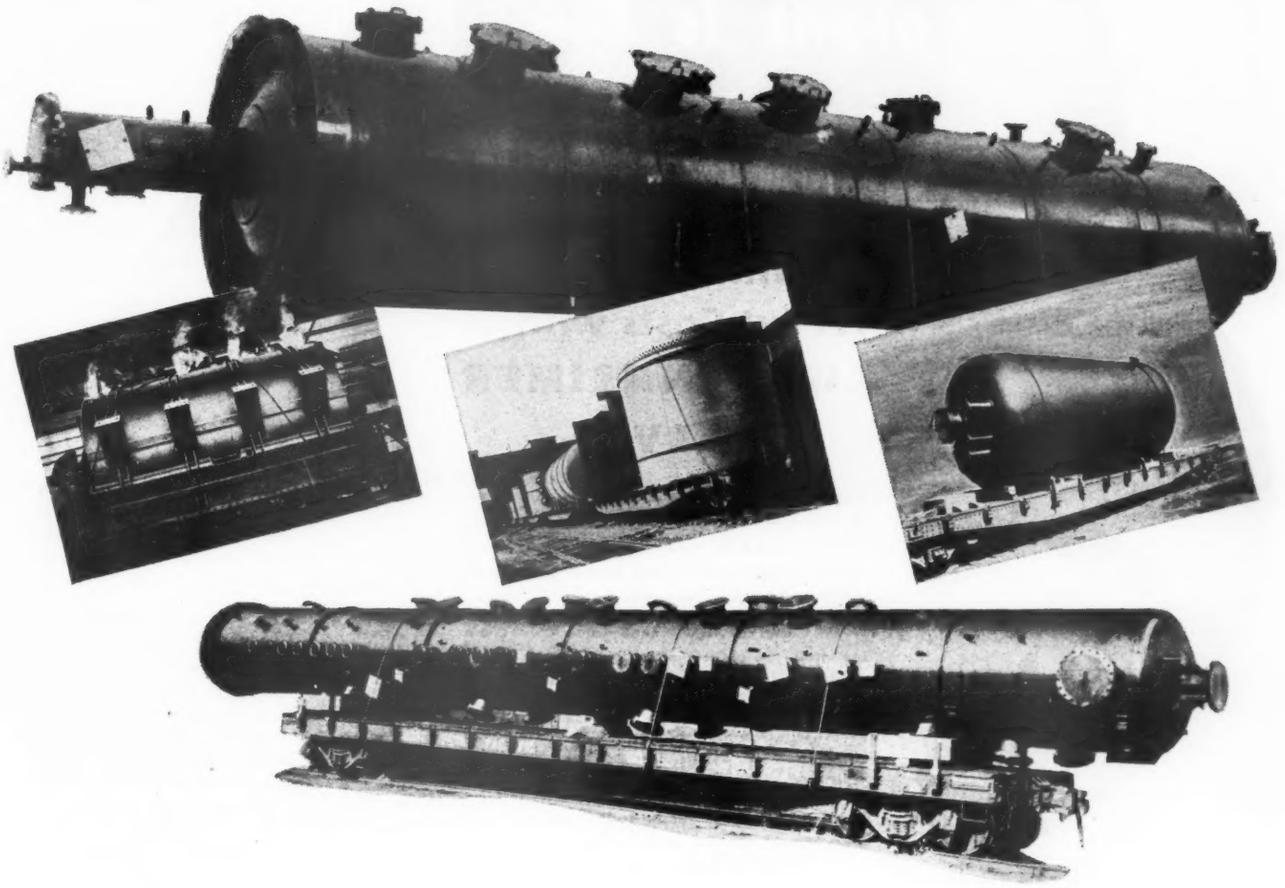


FIG. 8. EFFICIENCY vs. PRESSURE RATIO
PERFORMANCE TEST
10,000 c.f.m. COMPRESSOR "A"

FIG. 8A. DISCHARGE TEMPERATURE vs. PRESSURE RATIO
PERFORMANCE TEST
10,000 c.f.m. COMPRESSOR.



BUILT-IN DEPENDABILITY!



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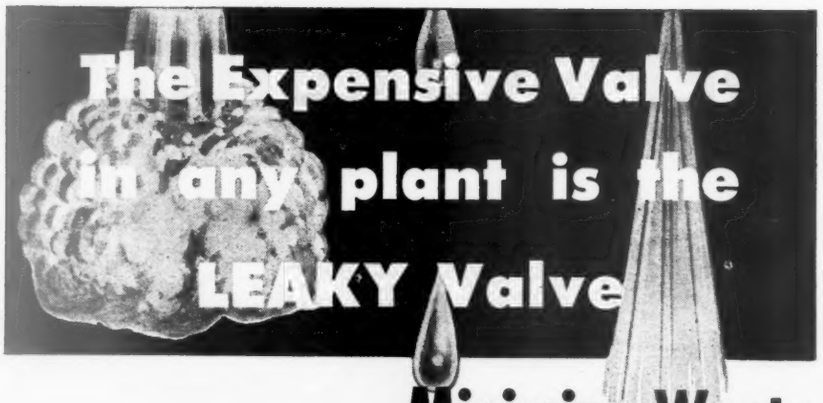

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Fig. 1640
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Fig. 1430
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ing over the square card cycle equal to the shaded area. The term, ideal compression, previously referred to, is shown on "C" Fig. 5, where isothermal compression betters the adiabatic line on "B" Fig. 5. It must be admitted these are hypothetical diagrams, to illustrate rather than record performance.

The power requirements for a 10,000 c.f.m. compressor are shown on Fig. 6. In order to get a clearer picture of the effect of adiabatic compressor efficiency on operating cost per year, a curve has been constructed (Fig. 7) over a range of efficiency from 72 to 84 per cent. The data assumed for this curve were $0.01 per kw-hr. and a 90 per cent driving engine efficiency, for a 10,000 c.f.m. unit operating at a pressure ratio of 3.0 to 1.0. By subtracting the price at any upper efficiency from a lower efficiency, the saving per year can be observed. The Elliott-Lysholm runs with efficiencies in the upper range, and due to the absence of rubbing surfaces within the air chamber there appears no reason why time should show detrimental effects. Also, by operating over the relatively flat portion of the curves shown on Fig. 8, even partial load conditions or low speed operation does not show evidence of expensive losses.

● **Conclusion.** Gas compression machines are today more than the secondary auxiliaries of their varied process application. Unless carefully selected, space, weight, and power can be unnecessarily wasted. Although an early realization of the gas turbine was primarily retarded for want of suitable metals, the successful gas turbine cycle was dependent on elevation of existing compressor efficiencies. Similar situations must exist with many process industries where compression machinery can be accredited as an appreciable percentage of the overall power picture, or conceivably, desired flow, pressure, speed requirements cannot be met with existing compression machinery.

The Elliott-Lysholm is contributing characteristics in a new combination, enlarging the scope and reducing the limitation formerly associated with compression machinery.

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"The Elliott-Lysholm Supercharger," Alf Lysholm, Ronald B. Smith, and W. A. Wilson, *SAE Journal*, Vol. 51, No. 6, June, 1943, p. 193.

"A New Rotary Compressor," A. J. R. Lysholm, *Inst. of Mech. Eng. Journal & Proceedings*, Vol. 150, No. 1, November, 1943, p. 11.

"Fundamentals of the Elliott-Lysholm Compressor," William A. Wilson and John W. Crocker. Presented ASME annual meeting, New York, New York, November 29, 1945.

Standard acquires fleet

The acquision of its own fleet for operation in the New York harbor area has been announced by Standard Oil Company of New Jersey. The company has purchased 6 tugs and 19 barges with carrying capacities ranging from 5000 to 30,000 bbl. Previously, the company contracted with outside carriers to transport all its products to its affiliates' terminals, dealers, and consumers.

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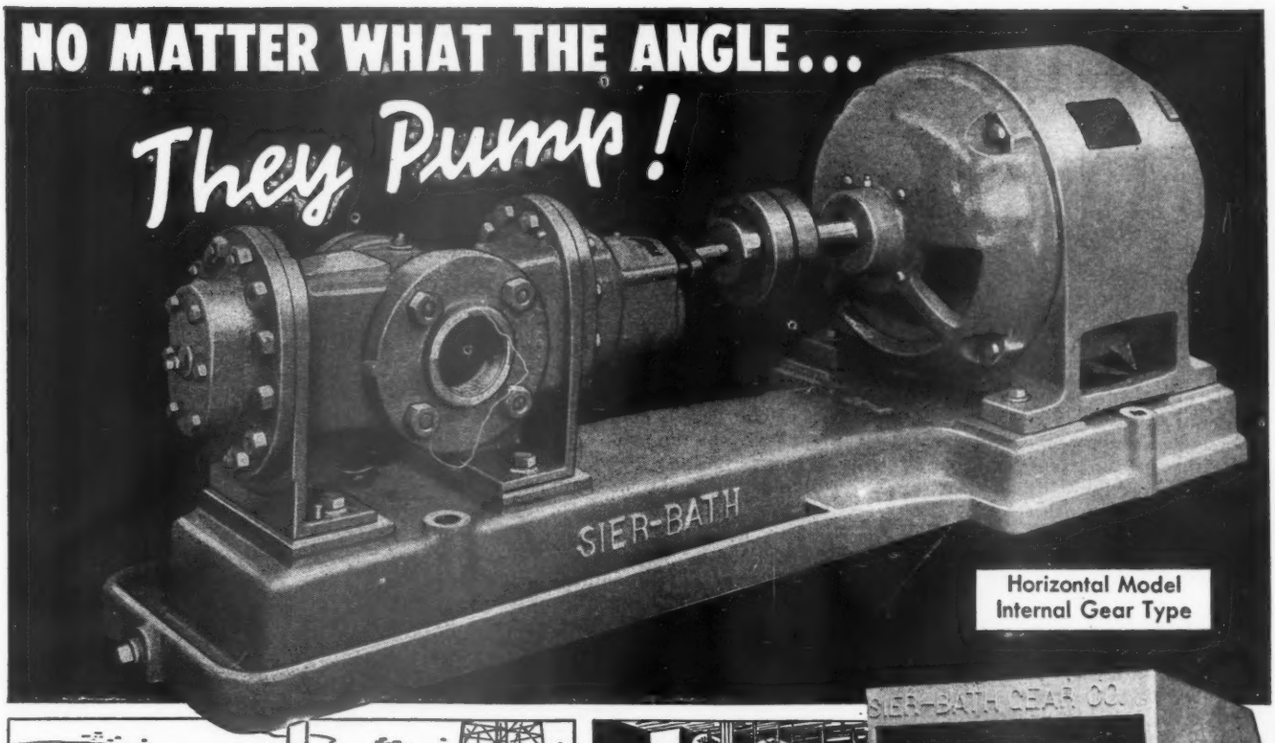

Horizontal Model
Internal Gear Type

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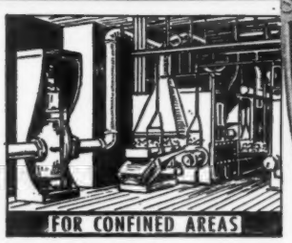
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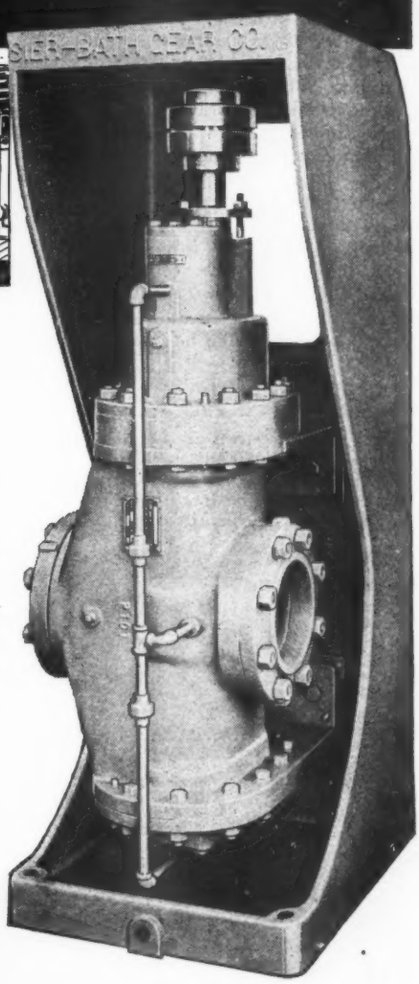

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PUMP DIVISION

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Molasses—
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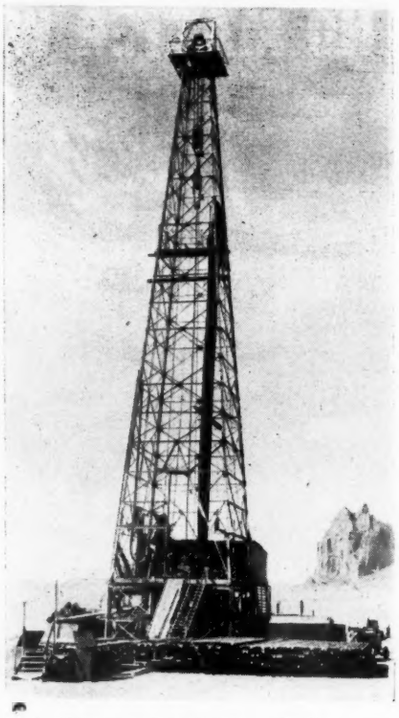
U. S. PRODUCES RECORD QUANTITY OF HELIUM



A Bureau of Mines drilling crew sinks a bit toward a reservoir of helium-bearing gas more than a mile below the surface. The derrick is 175 ft. high. In the right background is New Mexico's rugged Shiprock rising 1800 ft. above the plain. It is three miles from the drilling rig.

DISCLOSING figures on helium production, former Secretary of Interior Harold L. Ickes said that the U. S. Bureau of Mines plants in the last 5 fiscal years produced 370,787,000 cu. ft. of helium, or enough to inflate more than 600 patrol and scout blimps of the largest and latest type used by the Navy to wage war on Nazi submarines.

The Bureau's wartime helium output also would provide enough of this gas to inflate a fleet of more than 50 of the huge rigid-type dirigibles of the Graf Zeppelin II or Hindenburg class.

During the first World War when helium was little more than a laboratory curiosity, 3 small American plants produced a total of only 200,000 cu. ft. of helium. None of this reached Europe, although about 147,000 cu. ft. of gas in cylinders was awaiting shipment at an American port when that war ended.

The largest portion of the 1941-45 production went to the United States Navy for inflating the blimps used in coastal patrol and for convoy escort duty, but considerable volumes also were supplied to the Army, the Weather Bureau for use in meteorological balloons, and to medical, scientific and commercial users.

Military and non-federal demands for helium reached their greatest peak in history during December, 1943, when Bureau plants shipped 14,608,700 cu. ft. of the gas in cylinders and special tank cars. In the same month, the first of many all-time production records was established, the 3 plants in operation extracting 14,221,200 cu. ft. of helium.

This monthly output was surpassed only once—in September, 1944—when 4 plants of the Bureau extracted 14,297,700 cu. ft. of helium to set the highest monthly production record throughout the war.

Slightly more than a quarter of a century ago, helium was produced at a cost of about $2,500 per cu. ft. by then known laboratory methods, but during the war the gas was produced for considerably less than a cent per cubic foot.

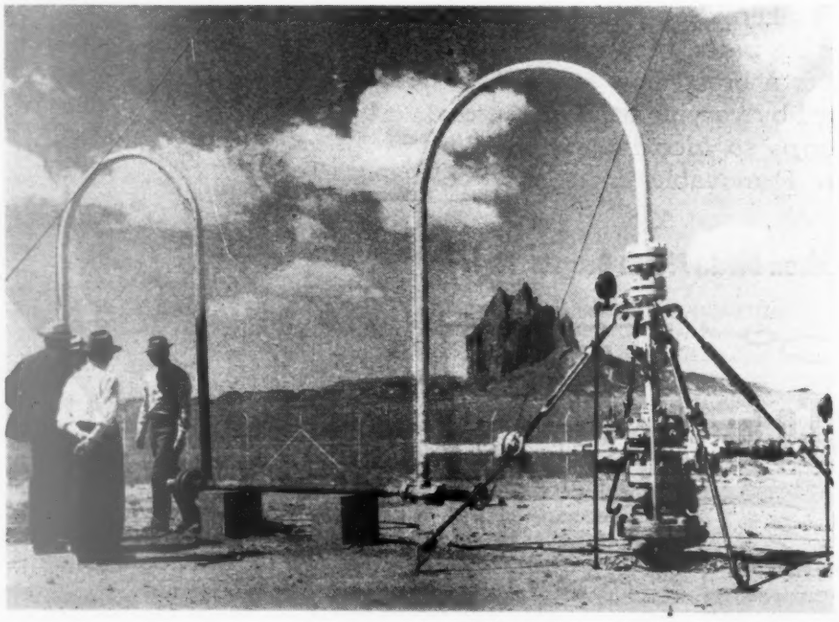
The Bureau of Mines, since 1925 the sole government agency charged with helium production, operated extraction plants at Amarillo and Exell, Texas, at Otis and Cunningham, Kansas, and at Shiprock, New Mexico, during the war. The Amarillo plant was supplied from the Government-owned 50,000-acre Cliffside gas field and the Shiprock plant tapped a Federally-controlled gas field, whereas the other plants extracted helium from privately-owned natural gas going to industrial markets.

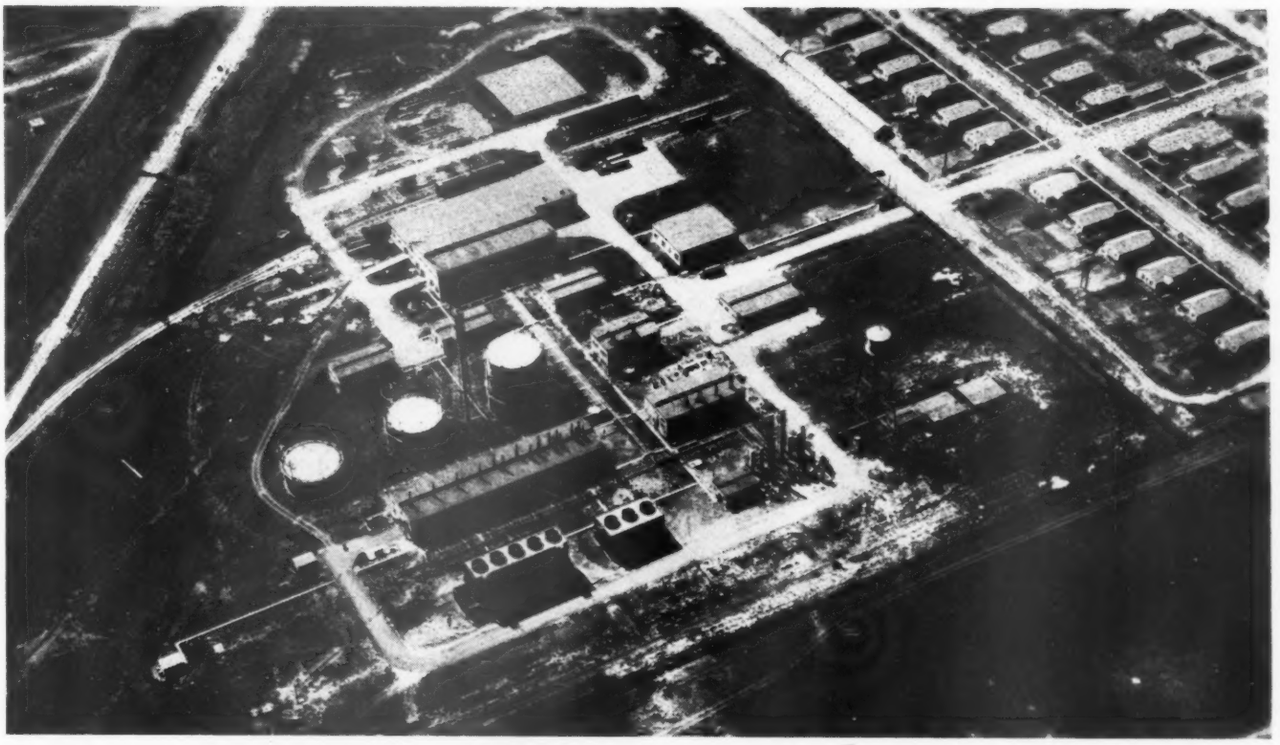
In releasing helium production figures compiled by Dr. R. R. Sayers, director of the Bureau of Mines, Ickes also disclosed that the United States had ample "insurance" against any interruption in the steady flow of the gas to military and Federal agencies and to medical, scientific and commercial groups. This was the Shiprock, New Mexico, plant, which was maintained in standby operating condition after its test run in March, 1944. Named in honor of the Navajo Indian tribes of New Mexico, this plant was ready to resume production if any of the other units broke down or if unexpected demands required additional helium that the other plants could not supply.

Four new helium extraction plants were built and existing production facilities at Amarillo were expanded by the Bureau in the short space of 3 years under a $16,000,000 expansion program launched soon after this country was forced into war with the Axis nations. Long experience in helium production and the perfection of more efficient extraction equipment enabled Bureau personnel not only to build the new plants in a comparatively short time, but also to reduce costs of production to the lowest point in history per 1000 cu. ft. of helium.

When Hitler invaded Poland in September, 1939—more than a year after Germany was denied the right to buy American helium—the Bureau had in operation only the Amarillo plant, which had been built in 1929 and had supplied domestic needs for more than a

The Christmas tree at the discovery well of the Rattlesnake gas field, the Navajo No. 1 helium gas well in New Mexico. This discovery led to the building of the Navajo plant.





Aerial view of the largest Bureau of Mines helium plant at Exell, Texas, a few miles north of Amarillo in the Panhandle. Storage tanks, compressor buildings, carbon dioxide removal towers and other facilities are shown.

decade. The outbreak of war in Europe and the intensified preparedness program of our own country caused many upward revisions of military estimates for helium, and the need for additional production facilities was foreseen many months before the United States entered the war.

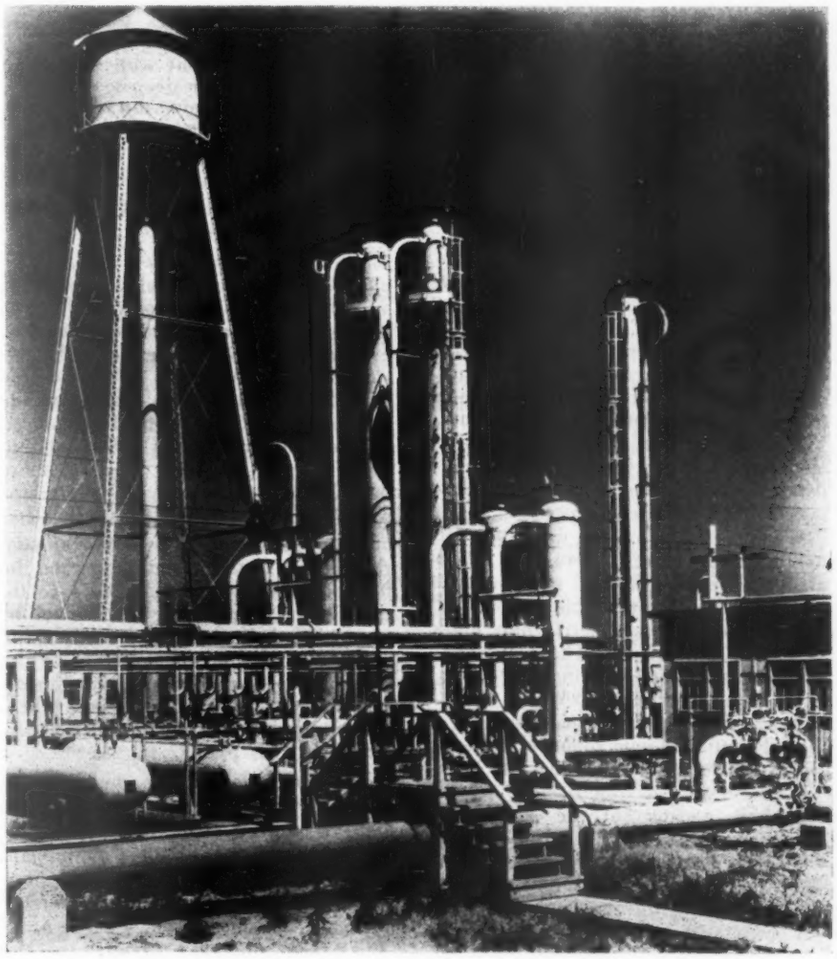
Tentative plans for expansion, however, were altered greatly after the Japanese attack on Pearl Harbor and specifications for the proposed plant at Exell, Texas, were revised to include additional helium separators. At the same time, enlargement of the Amarillo plant was proposed.

For the first 15 months of the war, during the construction of the Exell plant, the Amarillo plant bore the full burden of production. The first units at Exell started producing in March, 1943, and for several months following, while construction was rushed on other plants, the Amarillo and Exell operations were pushed far beyond their rated capacities to meet the demands for helium.

In July, 1943, the Amarillo plant reached its all-time monthly peak output of 4,617,900 cu. ft.—more than 50 per cent above its rated capacity. In the same month, the Exell plant produced 7,318,000 cu. ft., but this record output was eclipsed 3 months later, in October, 1943, when the yield was 8,238,800 cu. ft.—more than 60 per cent above rated capacity.

The Exell plant now is the largest helium development operated by the Bureau and in the first 8 months of service this plant had produced more helium than the original helium plant at Fort Worth, Texas, had extracted in its entire life of about 8 years. The daily rate of production at Exell exceeded the total quantity of helium produced during the first World War.

Water tower and carbon dioxide removal equipment of the Exell plant.



A decompression chamber used 20 years ago to experiment with helium-oxygen mixtures in alleviating the hazards of the "bends" in deep-sea diving and tunnel work. Improved models are now in use. When coming out of water, the diver spends a short time in this chamber, where nitrogen is replaced by helium gas to create a synthetic atmosphere.

The heavy burden placed on the Texas plants was relieved in October, 1943, when the second new plant, at Otis, Kansas, was placed in operation and immediately performed above its rated capacity. By January, 1944, when the Cunningham, Kansas, plant began to produce, the demand for helium had declined and this plant was not called upon to operate immediately at a high rate, but in September, 1944—the all-time record production month—this plant contributed 4,243,200 cu. ft. of gas, exceeding its rated capacity by 5 per cent.

When the Navajo plant was ready for operation in March, 1944, the other plants were meeting all requirements and it was decided that this unit should be operated for a trial period only until its output was needed. The plant performed satisfactorily during a test run of 18 days, producing 2,243,400 cu. ft. of helium, which was transported by a specially-built 90-mile pipe line to Gallup, New Mexico, for loading into tank cars.

Largely because of the successful Navy campaign against submarines, which had menaced Allied shipping in the Atlantic, military requirements for helium declined during October, 1944, and production dropped to about 10 million cu. ft. monthly and continued at about that rate until VE-Day in May, 1945.

Even before the defeat of Germany, however, a surplus of helium was accumulating and as a conservation move, this excess gas was piped back into the ground at the Government-owned Cliffside field near Amarillo. A 32-mile pipe line linking the Exell and Amarillo plants with the Cliffside field was placed in operation in January, 1945, and in the first year after its opening, more than 35 million cu. ft. of helium was placed back into the field for future use.

With the elimination of the submarine danger in the Atlantic after the defeat of Germany and improved conditions in the Pacific, the wartime job of producing helium was virtually completed and production activities at the Cunningham and Amarillo plants were suspended in July, 1945. Since then, current needs have been supplied by the Exell and Otis plants.

The Amarillo plant is being maintained in standby condition for immediate resumption of production on short notice, but the war-built Cunningham plant has been dismantled and the equipment utilized in other Bureau plants or by other Government agencies. The Amarillo plant, however, continues as the headquarters for an expanding helium research program.

Two of the Navy's standard type patrol blimps set a 1900-mile nonstop record for nonrigid airships in the summer of 1944 by flying to the Mediterranean area from Newfoundland to join 6 other nonrigid type craft dispatched for anti-submarine and convoy duty. The blimps were instrumental in ending the threat of submarines sneaking into the Mediterranean through the Straits of Gibraltar.

Helium has been used since 1921 in American Naval blimps and Army balloons and its use by the Weather Bureau and in medicine and commercial processes has increased steadily in recent years. Aside from its important wartime service to the Navy and Army, helium assisted the Weather Bureau in charting high altitude currents for stratosphere flights, opened up new fields in magnesium-welded fabrication of heavier-than-air craft, enabled divers to go to the greatest depths they ever reached below the surface of the sea, and relieved human suffering by alleviating certain respiratory ailments and caisson disease, commonly known as "the bends."

In summing up helium production activities during the war, Ickes declared:

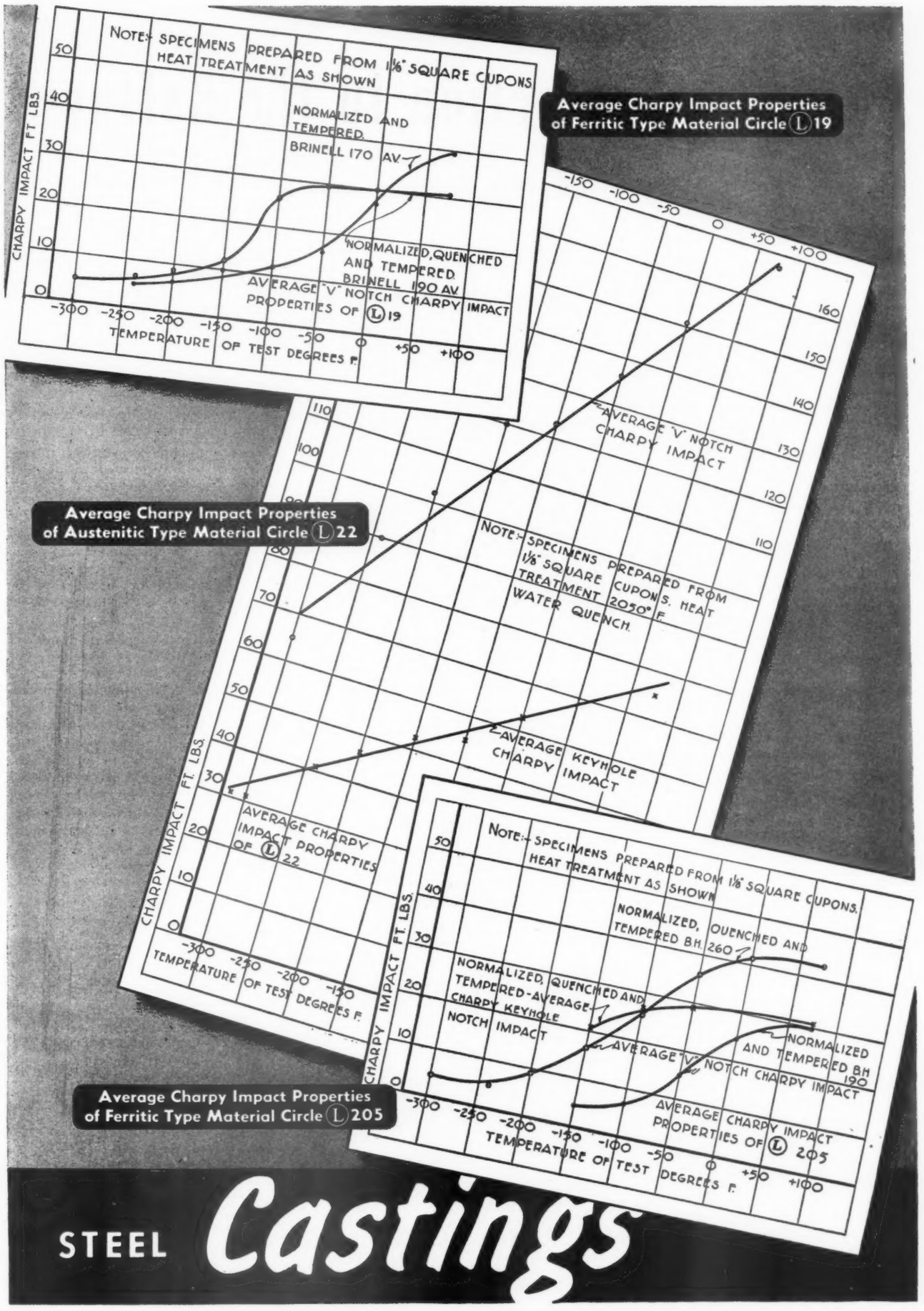
"The Bureau of Mines has performed a task which takes front rank in war production. The Bureau helium plant workers, who necessarily had to maintain a 24-hour day, seven-day week vigil in extracting this precious gas, deserve a lasting vote of thanks for their faithfulness.

"Without such a staff vitally interested in meeting demand and keeping operations moving with a minimum of breakdowns, this Nation could not have shared such an outstanding record. Even a temporary breakdown in the helium output might have been the cause for the sinking of an Allied ship in the Atlantic.

"It was Rear Admiral Charles E. Rosendahl, present chief of the Naval Airship Training and Experimental Command at the United States Naval Air Station, Lakehurst, New Jersey, who recalled several months ago that the Navy's blimp 'watchdogs' had maintained in World War II their enviable record established during the first World War and as a result not a single one of the thousands of ships under escort by blimps has ever suffered a successful attack by a submarine.

"This achievement alone is sufficient to make the helium workers proud, but more than that, they have insured the United States a monopoly on helium for a long time to come and already millions of cubic feet of the gas are going back into the Cliffside reservoir for peacetime use.

"Three of the Bureau's plants—Amarillo and Exell, Texas, and Otis, Kansas—were awarded the Army and Navy E during the war and workers of the Cunningham, Kansas, plant were in line for this merited honor when the war ended and production declined. In my estimation, they, too, have received the E Award from a grateful Nation." ★ ★ ★


Average Charpy Impact Properties of Ferritic Type Material Circle (L) 19
NOTE:- SPECIMENS PREPARED FROM 1⅛" SQUARE CUPONS HEAT TREATMENT AS SHOWN
NORMALIZED AND TEMPERED BRINELL 170 AV.
NORMALIZED, QUENCHED AND TEMPERED BRINELL 190 AV.
AVERAGE "V" NOTCH CHARPY IMPACT PROPERTIES OF (L) 19
CHARPY IMPACT FT LBS
TEMPERATURE OF TEST DEGREES F.
Average Charpy Impact Properties of Austenitic Type Material Circle (L) 22
NOTE:- SPECIMENS PREPARED FROM 1⅛" SQUARE CUPONS. HEAT TREATMENT 2050° F. WATER QUENCH.
AVERAGE "V" NOTCH CHARPY IMPACT
AVERAGE KEYHOLE CHARPY IMPACT
AVERAGE CHARPY IMPACT PROPERTIES OF (L) 22
CHARPY IMPACT FT. LBS.
TEMPERATURE OF TEST DEGREES F.
Average Charpy Impact Properties of Ferritic Type Material Circle (L) 205
NOTE:- SPECIMENS PREPARED FROM 1⅛" SQUARE CUPONS. HEAT TREATMENT AS SHOWN
NORMALIZED, QUENCHED AND TEMPERED BH 260
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AVERAGE "V" NOTCH CHARPY IMPACT
NORMALIZED AND TEMPERED BH 190
AVERAGE CHARPY IMPACT PROPERTIES OF (L) 205
CHARPY IMPACT FT. LBS.
TEMPERATURE OF TEST DEGREES F.
STEEL Castings

Cathodic Protection in the Refinery

By **D. HOLSTEYN,** Shell Oil Company, Inc.

EXCLUSIVE

DURING the first years of construction, pipe line systems in the Houston Refinery of the Shell Oil Company, Inc., had protective coatings applied in order to combat soil corrosion. These protective coatings were omitted in the latter part of 1933, and since that time for the most part pipe lines have been laid without any protective coatings.

Chemical contamination of the soil accelerated the normal rate of attack, and soon leaks made their appearance. A rapid increase of leaks during 1938 warranted a corrosion survey that revealed a serious condition, which was attributed to electrochemical action.

Cathodic protection, an electrical method for minimizing or preventing soil corrosion, was recommended. During the years 1939 and 1940, a few experimental cathodic units were installed in order to study their effects on corrosion, their behavior and their economics. It was found that the method could definitely and economically be applied on an intricate pipe line system, such as is commonly found in refineries.

● **Cathodic unit design.** A study of papers published on the subject of cathodic unit design for single pipe lines across country gave some idea of how to approach the problem.[1] Data obtained from the experimental units, however, indicated that the conventional layout of a ground bed for a single, long run of pipe line could not easily be applied to an intricate pipe line system. Because such a system varies in pipe diameter from ½ in. to 30 in., placed at different elevations, crossing and paralleling each other at distances from a few inches to several feet, and because there is limited space in the refinery for ground bed locations, the necessary protective potentials between soil and pipe varied in the extreme due to a shielding effect among the lines. This shielding resulted in overprotection for some areas of the lines, whereas insufficient protection existed for others. An even distribution of protective potentials can theoretically be obtained by inserting resistances at the proper point in the electrical circuit, but this has not proved practical.

An alternate method for accomplishing an even distribution of the protective potentials involves proper arrangements of the anode or ground bed layout and must take into consideration the conductivity of the soils, the electrical resistance of the surface of the lines, and the geometrical relations between the anode and the underground lines.

Discussion of costs and results of installing equipment to combat corrosion in Gulf Coast plant.

In facilitating a more convenient method of multiple anode system design, other than by the costly trial-and-error method, curves pertaining to the behavior of a ground rod and a series of ground rods, discharging current to earth, were plotted as shown in Fig. 4.[1, 2, 3] These graphs show that the resistance to ground may be manipulated by the length and the diameter of a ground rod as well as by the number of rods and the spacing between them. Also, the approximate economic balance of increasing the number of rods with a resulting saving in the cost of ground bed renewals and lower power cost is illustrated. Often the design of a cathodic unit calls for 3 or 4 separate ground beds, totaling 30 to 40 ground rods and operating from one rectifier.

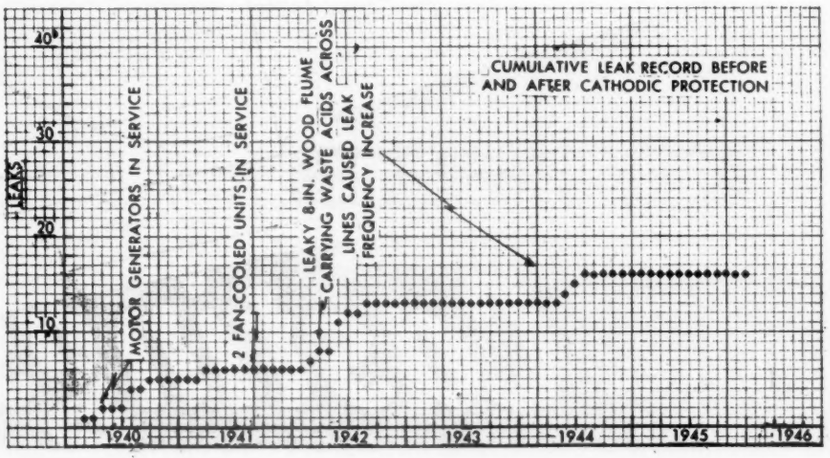
The resistance to earth, with respect to each leg of the ground bed system, can be calculated from these graphs so that no resistors are necessary for controlling the required current discharge to earth for each leg of the ground bed. Referring to curve A, Fig. 4, the resistance to earth of a vertical anode for a given length and diameter, placed in uniform soil of 1000 ohms/cc, may easily be read on the vertical axis.

For horizontal anodes the resistance may be read from curve B.

When a number of vertical anodes, electrically interconnected in parallel, are forced to discharge current to earth, the total resistance to earth cannot be calculated according to the parallel circuit formula. An additional resistance is introduced by the capacitance effect of the earth and this effect is governed by the length and the diameter of the anodes, as well as the distance between them.

The capacitance effect is the combined electrostatic capacity in free space of the anode and its image above the surface of the ground, completing a sphere, whose capacitance is numerically equal to its radius. There is no means known for computing the exact value of the electrostatic capacity, but an approximation is given by the equation shown on curve C of Fig. 4. The references cited in the bibliography also show that if the radius of the anode hemisphere and soil resistivity are known, the resistance to earth at any distance from the hemisphere can be computed. Also, it is possible to calculate the distance at

FIG. 1.



[1]References will be found at end of article.

COST-CONSCIOUS?

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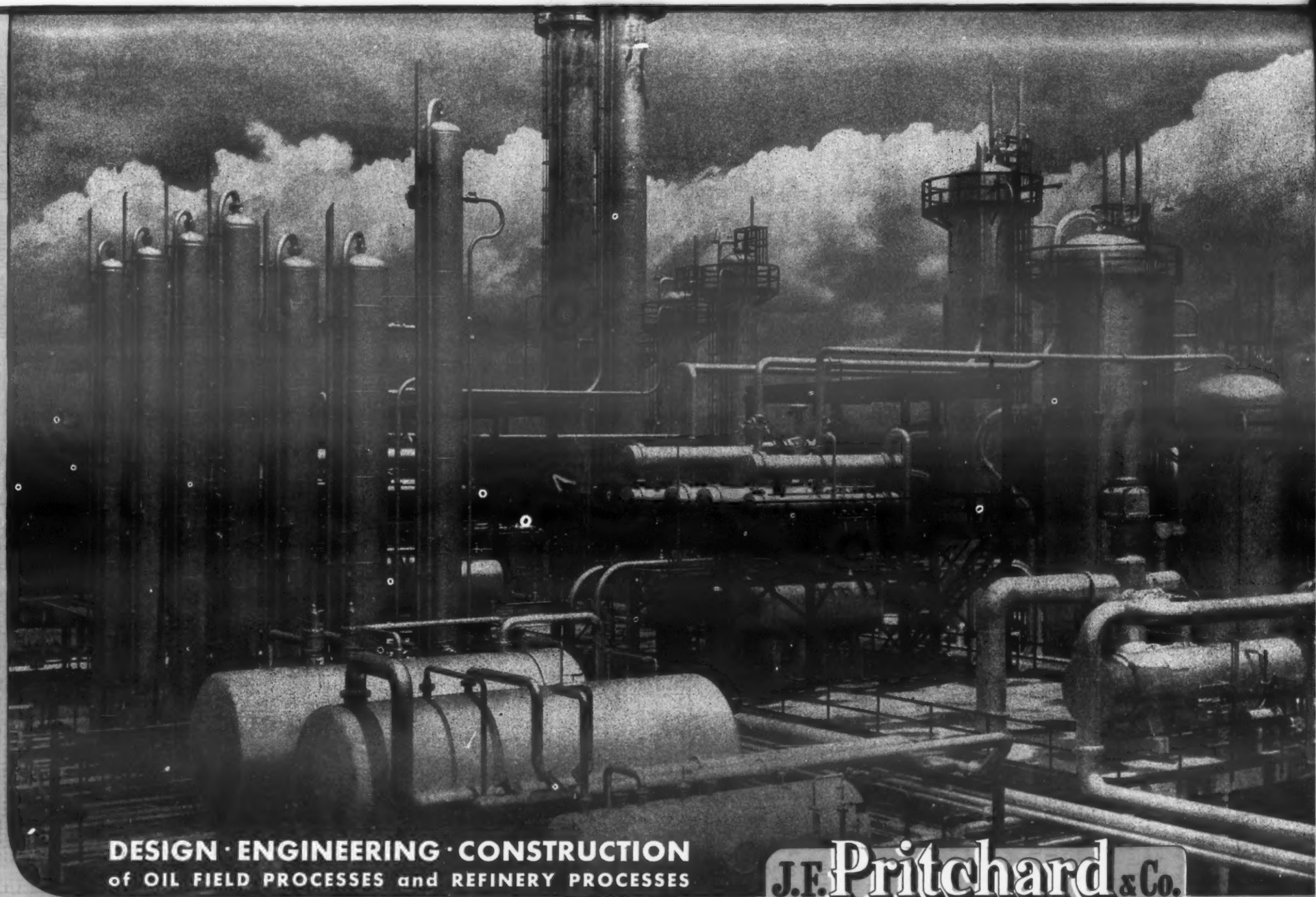

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which the resistance equals any percentage of the total.

The per cent of the resistance of one anode for a number of anodes spaced a given distance apart may be readily interpreted from curve D of Fig. 4.

For example, it is desired to know the total resistance of 4 ground rods or anodes 8 ft. long, 5 in. in diam., placed in a soil of 2000 ohms/cc and spaced 10 ft. apart. The resistance of one such ground rod from curve A of Fig 4:

$$\frac{2.64 \text{ ohms} \times 2000 \text{ ohms}}{1000 \text{ ohms}} = 5.28 \text{ ohms}$$

The radius of the rod's hemisphere from curve C = 2 ft. The distance between rods is thus:

$$\frac{10 \text{ ft.}}{2 \text{ ft.}} = 5 \text{ hemispheres}$$

From curve D, the line indicated by the number 5 on the horizontal axis is followed upward until it intersects the curve of the required number of anodes, in this case 4 anodes. The per cent resistance of 1 anode is read on the vertical axis as 32 per cent of the value read on curve A. The total resistance is thus:

$$\frac{5.28 \text{ ohms} \times 32}{100} = 1.69 \text{ ohms}$$

If the spacing between anodes had been 100 ft., equaling 50 hemispheres, the per cent resistance of one anode would read 26 per cent or a total resistance of:

$$\frac{5.28 \text{ ohms} \times 26}{100} = 1.37 \text{ ohms}$$

If a resistance to earth of approximately 0.25 ohm is desired, under conditions as stated in the above example, the number of anodes necessary to obtain this resistance may be read from curve D Fig. 4. As the desired resistance (0.25 ohm) is approximately 5 per cent of the resistance of 1 anode (5.28 ohms), the point of intersection at 5 per cent in the vertical axis and 5 hemispheres on the horizontal axis indicates a total of 24 anodes.

From laboratory investigations and experiences from cathodic unit installations, approximately 3 milliamperes per sq. ft. of bare line are required to produce necessary protective potentials in a soil of about 1000 to 1500-ohm resistivity. For lower resistance soils, current densities of 5 to 10 milliamperes per sq. ft. of bare pipe may be necessary, whereas 1 milliampere per sq. ft. may be sufficient for soils of 3000 to 5000-ohm resistivity.

If an area is to be placed under cathodic protection, usually the "hot spots" or corroding areas and soil conditions are known from data accumulated by bell hole inspections or leak records, or from corrosion surveys.[5] The geographical layout of the underground structures may be obtained from available refinery prints and the area of piping in question may be calculated.

If the above-named conditions are known, a rectifier may be designed for the necessary voltage and current requirements based on the number of anodes used. The rectifiers are sized about 30 per cent over the theoretical requirements to allow for increase in resistance of the ground bed due to deterioration and for the expansion of the ground bed, should it become desirable.

● **Power equipment.** The equipment used as a source of power must be able to supply large currents at low voltages, be economical to operate, and require a minimum of attention and maintenance. The power may be supplied by motor generators, windmill generators, batteries, or various types of rectifiers.

Motor generators are the most efficient, but require considerable attention and maintenance.

Windmill generators are dependent on weather conditions and are not considered satisfactory for refinery use.

Storage batteries are expensive, have a limited power output and require considerable attention.

Zinc or magnesium, electrically attached to the pipe, has not been used so far in the refinery.

Copper oxide rectifiers of different models serviced by the refinery mains of 440 volt or 220 volt single phase, have been used throughout. These include the fan-cooled, the self-cooled, and oil-immersed models. The last is the most suitable for refinery use, the elements are free from atmospheric corrosion attacks, and they are rugged and dependable.

● **Cost and results of the installations.** At present there are 26 cathodic units in operation and more installations are to be constructed. The cost per installation varies from $80 to $1200. The average capacity per unit in use is 10 volt—50 amp. d.c.—and may protect an area from 10,000 to 25,000 sq. ft. of bare line pipe, depending upon the geographical layout of the lines in the area to be protected and soil conditions. The annual operating cost has averaged $200 per installation per year including supervision, repairs, renewals to ground beds, and power cost.

Fig. 1 shows the effects of 2 cathodic unit installations upon the leak frequency of 10 parallel lines, varying in size from 4 in. to 12 in. The lines are spaced approximately 1 ft. apart, differ slightly in elevation, and do not have protective coatings. The soil is contaminated with chemicals and refinery wastes.

FIG 2.

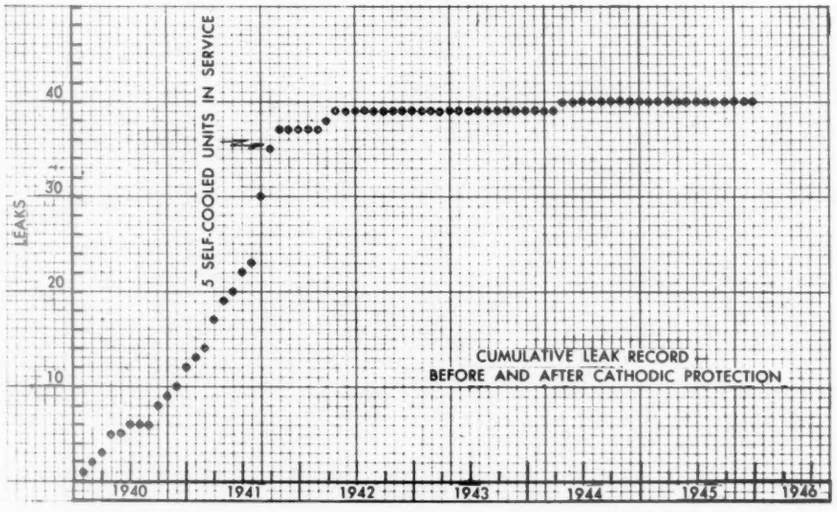
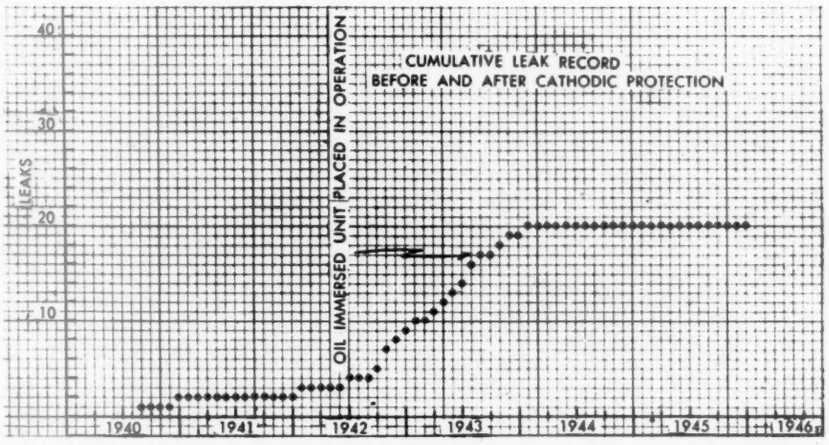


FIG. 3.



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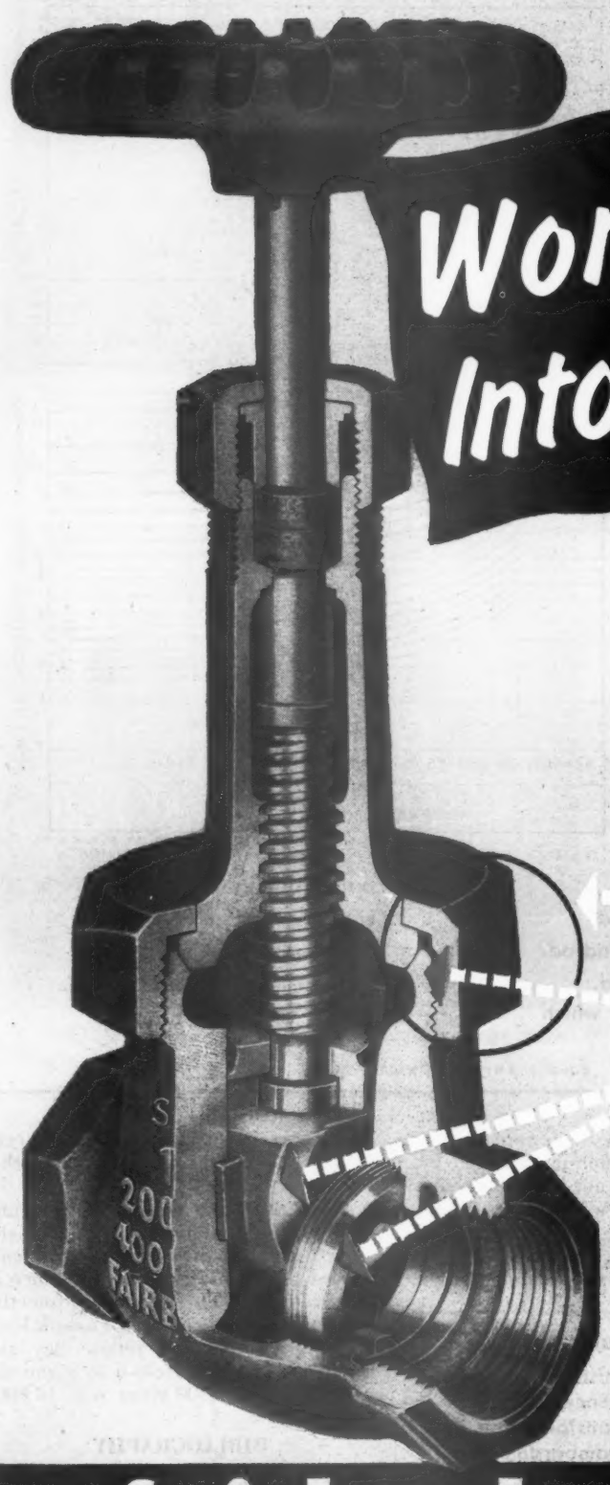

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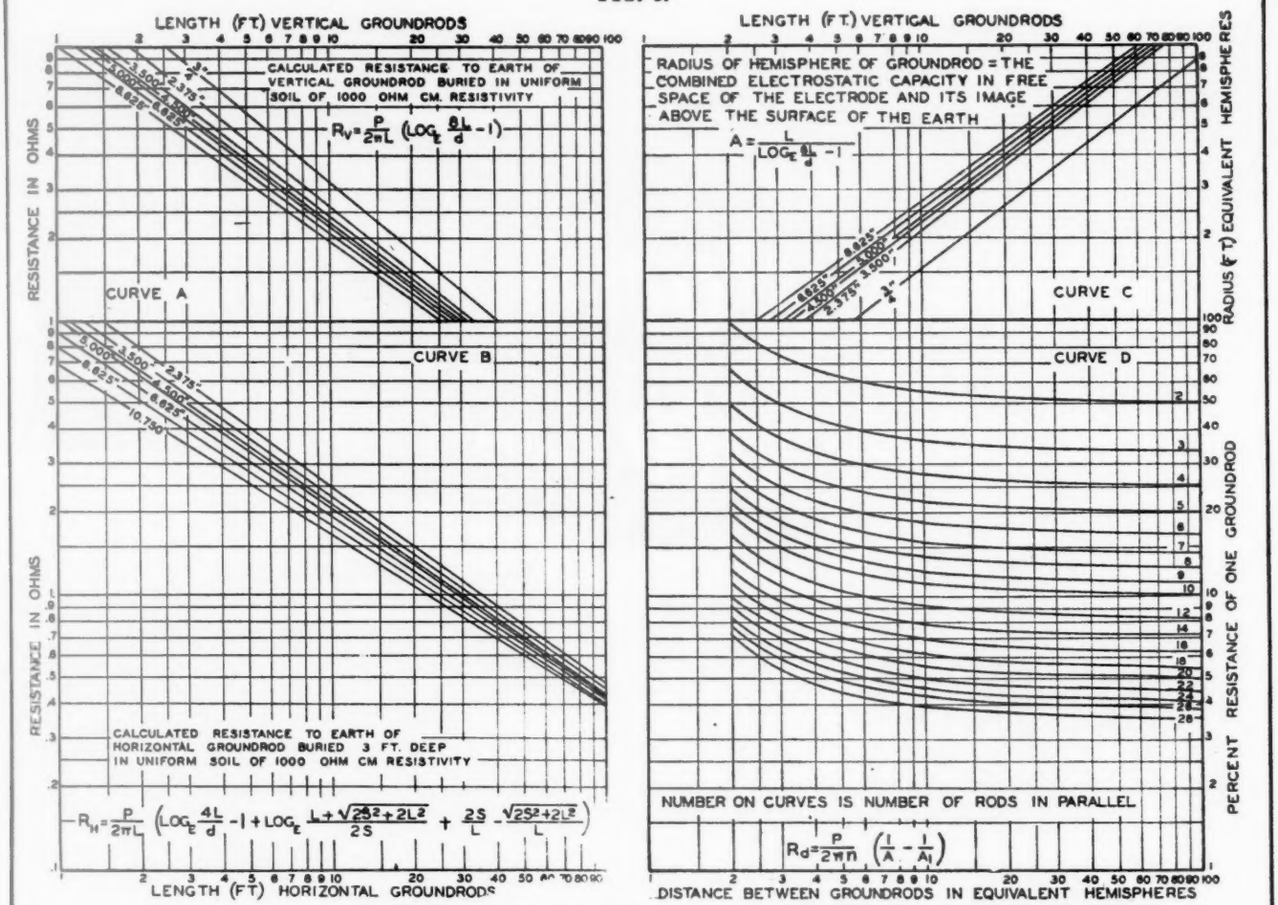
FIG. 4.


LENGTH (FT) VERTICAL GROUNDRODS
CALCULATED RESISTANCE TO EARTH OF VERTICAL GROUNDROD BURIED IN UNIFORM SOIL OF 1000 OHM CM. RESISTIVITY
$R_V = \frac{P}{2\pi L}\left(\log_e \frac{8L}{d} - 1\right)$
CURVE A
CURVE B
RESISTANCE IN OHMS
CALCULATED RESISTANCE TO EARTH OF HORIZONTAL GROUNDROD BURIED 3 FT. DEEP IN UNIFORM SOIL OF 1000 OHM CM RESISTIVITY
$R_H = \frac{P}{2\pi L}\left(\log_e \frac{4L}{d} - 1 + \log_e \frac{L+\sqrt{2S^2+2L^2}}{2S} + \frac{2S}{L} - \frac{\sqrt{2S^2+2L^2}}{L}\right)$
LENGTH (FT) HORIZONTAL GROUNDRODS
RADIUS OF HEMISPHERE OF GROUNDROD = THE COMBINED ELECTROSTATIC CAPACITY IN FREE SPACE OF THE ELECTRODE AND ITS IMAGE ABOVE THE SURFACE OF THE EARTH
$A = \frac{L}{\log_e \frac{8L}{d} - 1}$
CURVE C
CURVE D
RADIUS (FT) EQUIVALENT HEMISPHERES
PERCENT RESISTANCE OF ONE GROUNDROD
NUMBER ON CURVES IS NUMBER OF RODS IN PARALLEL
$R_d = \frac{P}{2\pi n}\left(\frac{1}{A} - \frac{1}{A_1}\right)$
DISTANCE BETWEEN GROUNDRODS IN EQUIVALENT HEMISPHERES

R_V = Resistance to earth of vertical groundrod.
R_H = Resistance to earth of horizontal groundrod.
R_d = Resistance in per cent of one vertical groundrod.
A = Radius of hemisphere of vertical groundrod.
A_1 = Distance from center of hemisphere to which R_V is computed.
P = Earth resistivity ohm cm.
L = Length of rod in cm.
d = Diameter of rod in cm.
S = Depth of horizontal rod in cm.
n = Number of rods in parallel.

Equations by H. B. Dwight.

the moisture content averages 35 per cent, the pH value varies from 4.5 to 5.5, and the resistivity changes from less than 100 ohms/ccm. to 600 ohms/ccm.

Fig. 2 shows the results of 5 cathodic units for an area containing 18 parallel lines and 14 cross lines. The lines vary in size from 2 in. to 30 in., are irregularly spaced and differ in elevation by 3½ ft. The lines do not have protective coatings. The soil is a dark loam mixed with yellow and blue clay, contaminated with refinery wastes, chemicals, and oil cokes. The pH value varies from 4.5 to 7 and the resistivity from 300 ohms/ccm. in spots to 10,000 ohms/ccm. in other places.

Fig. 3 illustrates the effect of one unit upon 37 parallel lines, varying in size from 2 in. to 12 in. The lines are evenly spaced, have only a slight difference in elevation, and do not have protective coatings. The soil consists of a dark loam mixed with blue and yellow clay and varies in pH value from 6 to 8 and the resistivity from 1400 ohms/ccm. to 8000 ohm/ccm.

Atomic methods for increase of petroleum

A group of Massachusetts Institute of Technology scientists in a report to the American Chemical Society offered laboratory evidence in support of a theory that crude oil is formed by the radioactive transformation of familiar organic substances—brought about by atomic bombardment of matter in the bowels of the earth.

That most petroleum originates in the remains of plants and animals that have been deposited on the ocean bottom and have then been buried by layers of mud and sand is the generally accepted theory on how petroleum is formed in the earth. This would mean that the rich oil deposits of Texas, Oklahoma and other states originated in inland seas in the dim geological past.

If the MIT investigators' hypothesis proves sound, it would mean a revolution in seeking oil and would make fabulous additions to oil supplies.

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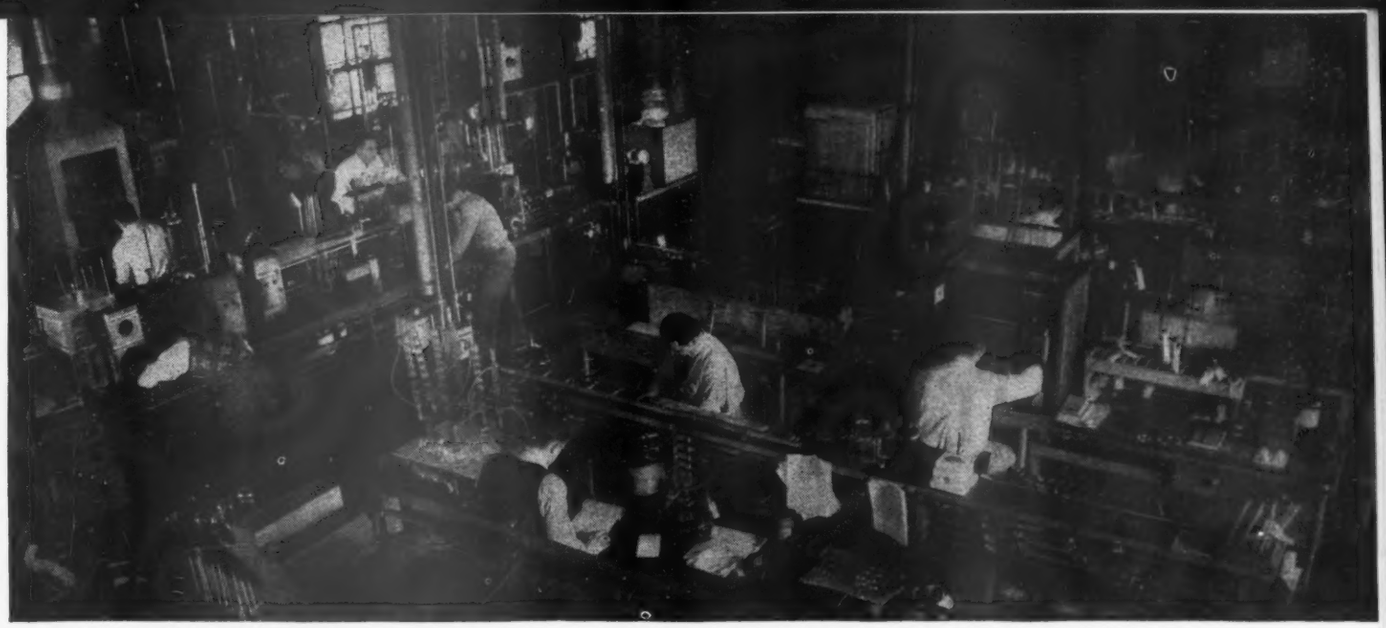
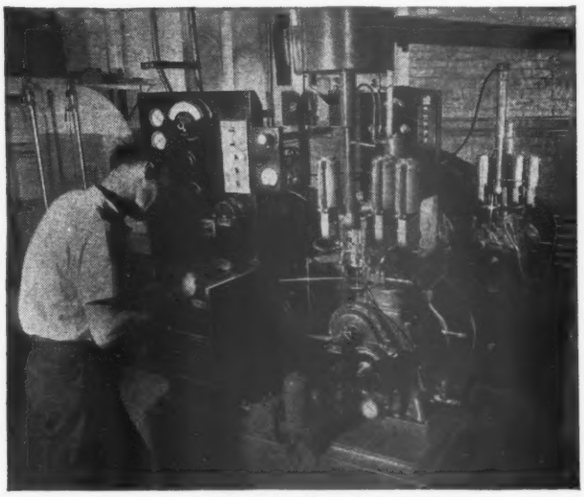


5 QUALITATIVE ANALYSES of feeds and products from all pilot runs are continuously performed in the Analytical Laboratory. Here, physical and chemical properties and other pertinent factors are assessed and carefully charted. When combined with utility statistics, operating conditions, and volume of yields from the pilots themselves, these data form a thoroughly sound basis for the final analysis by process engineers.



6 MOTOR FUEL COMPONENTS are engine tested. Operating as an adjunct to the Analytical Laboratory, test engines measure octane rating and lead susceptibility of gasolines. Gaseous components are analyzed in the Mass Spectrometer. Catalyst structure is continuously studied in X-Ray diffraction equipment. The comprehensive findings obtained from such modern analytical instruments form an important part of the complete report of the Analytical Laboratory.

7 HERE THE FACTS ARE TABULATED. And then, in the Process Design and Economics group, the complete data of the refiner's proposed and present refinery operations are weighed, with reference to specialized local costs – labor, utilities, transportation – and the specialized price structure for products in the proposed areas, both as of today and the foreseeable future. From this weighing of data comes a dependable, documented recommendation on which action can be safely taken.

The technique outlined on these pages is regularly applied by Kellogg to answering the questions of its customers seeking to determine whether earning power of a proposed operation is favorable. Once this all-important factor is established, the data are at hand for designing the customer's individual plant . . . and for constructing it with every assurance that it will operate as predicted, from initial run throughout its planned future.

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PRACTICAL REFRIGERATION *for* NATURAL GASOLINE PLANTS*

By **R. W. HEATH, J. B. TAYLOR, JR.** and **P. W. HILL**†

THE advantages of refrigeration in natural gasoline absorption plant operations do not seem to be as generally appreciated as is justified. We are at a loss to understand the reason for this since refrigeration units have been used in a few natural gasoline plants for a number of years. The literature is also reasonably complete on the theoretical design[1] and advantages[2] of a modern unit. It does appear, however, that a more detailed study of the practical design, operating problems, and actual data may serve to emphasize the value of refrigeration in a modern low pressure absorption plant.

In California there now seems to be a very definite interest developing in this type of unit. Possibly this is the normal reaction that may be expected as a result of the installation of at least 3 refrigeration units in existing low pressure absorption plants during the last year and the inclusion of such a unit in a new plant that is now being constructed. These existing refrigeration units have all proved extremely economical to install and are efficient and simple to operate. It is therefore natural that the interest in this type of operation will grow as this information is appreciated. For the same reason additional installations of refrigeration units should be expected in the near future. The writers have been directly interested in 2 of these recent refrigeration plant installations and their actual design and operation is the real basis of this paper.

We will limit our consideration to the use of propane as a refrigerant and to the application in low pressure absorption plants with absorber pressures of less than 100 lb. per sq. in. Propane has the advantage of being inexpensive, readily available, and of high refrigerating efficiency. Operating pressures are above a vacuum that precludes air contamination and all pressures allow reasonable pipe line sizes without serious pressure drops.

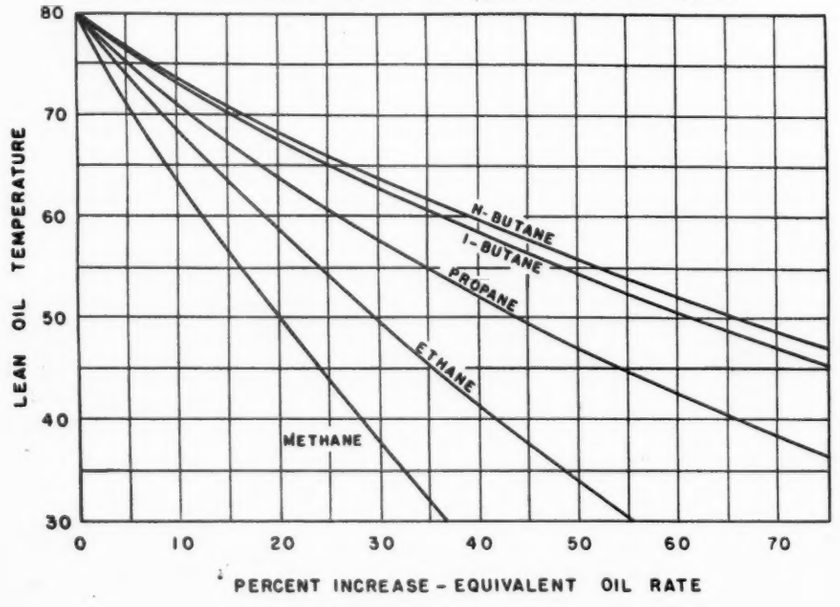
The advantages of refrigeration are not alone due to the reduction in vapor pressures but also the fact that the heavier fractions are reduced to a relatively greater extent than are the lighter hydrocarbons below the butanes. As a result there is a greater spread of vapor pressures between the various hydrocarbons at the lower temperatures. This results in better separation of the fixed gases from the fat oil tank and wherever colder temperatures are developed. An example of this condition is shown on the accompanying curve (Fig. 1) showing oil temperatures against increased absorption below 80°F. in terms of increased oil rate to obtain equivalent results. From this curve it can be found, for example, that by lowering the oil temperature from 80° to 55°F. that this is equivalent to a 50 per cent increase in oil rate at 80°F. insofar as the butanes are concerned but only 35 per cent for propane, 24 per cent for ethane, and 17 per cent for methane. This advantage of selective absorption is not available by the other means of increasing plant capacity such as increased oil rate, lighter mol weight oil, or increased pressures.

The costs of installing a refrigeration unit capable of subcooling the lean absorption oil by 25°F. are small in terms of equivalent oil rate and it would appear that such a unit might easily be justified in a new plant. This would be especially true where the volume of gas to be treated may be expected to remain relatively constant and the prospects of future additions to the plant to be unlikely. It is also true where poor conditions of atmospheric cooling are obtained that would require an oil circulation that could not be justified when compared with the corresponding costs of using a lower oil circulation and installing propane refrigeration to procure the same results. Where future expansion seems likely, it would appear reasonable to design the plant with the thought that refrigeration might be added later.

Benefits of refrigeration are more easily appreciated in existing plants where it is necessary to increase the plant capacity for the purpose of extracting additional light hydrocarbons or to regain a plant efficiency that has been reduced due to additional load. Under these conditions the costs of installing the additional equipment for the necessary oil circulation (and additional plant units) can usually be shown to be much greater than the corresponding cost of installing a refrigeration unit to accomplish the same results. In addition the actual installation of a refrigeration unit is a simple problem and can be accomplished without the usual interference with the existing plant units. Our studies indicate that the additional refrigeration to increase the plant capacity by 50 per cent could be installed in our plants for about one-half the cost that would have been required by a relative increase in oil rate.

In addition to the savings in first costs for a refrigeration system cooling the lean absorption oil, there is also a very definite savings in operating costs. The

FIG. 1. OIL TEMPERATURES VS. EQUIVALENT OIL RATE.



*Presented at California Natural Gasoline Association January meeting.

†All three writers are connected with Signal Oil and Gas Company. R. W. Heath is vice president in charge of gas department; J. B. Taylor, Jr., is assistant superintendent of gas department, and P. W. Hill is senior gas engineer.

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fuel requirements of a refrigeration system are practically limited to the engine fuel that is nominal, whereas the fuel required to both heat and pump increased quantities of absorption oil would amount to considerably more. Also, the other operating and maintenance costs are low in comparison with the costs for the additional boilers, stills, pumps, exchangers, and their auxiliaries.

Refrigeration units can be designed to maintain minimum oil temperatures where the plant is overloaded and can utilize the lowest temperatures that can be obtained in cold weather. When the temperatures that can be obtained under this arrangement are lower than necessary or when freezing or hydrate formation occurs, a back pressure valve, or temperature operated motor valve can be installed in the vapor line from the chillers. In cases where constant plant operating conditions are desired, a temperature controllor on the oil will be useful. This may be especially true when the existing absorption plant is overloaded at some one point such as the stabilizer. In such a case a controlled oil temperature may help maintain uniform vapor volumes and quality of products that would smooth out these plant operations.

In fact, the refrigeration unit complements the absorption unit unusually well, for it supplies the maximum cooling when the atmospheric cooling is the poorest. When the atmospheric cooling is less efficient and the temperature of the lean absorption oil to the refrigeration system is relatively high there is an increased temperature difference between the oil and the propane that results in increased cooling. This additional cooling in turn increases the volume of vapors to be handled by the compressor and therefore raises the propane pressure and temperature but not sufficiently to entirely offset the increased cooling. The fact that the compressors are more efficient with a higher intake pressure is advantageous to increased refrigeration. A compressor with clearance pockets has a still higher ratio of efficiency at higher intake pressure. The resulting lowered compression ratio allows its greatest advantage and maximum refrigeration at those times when the absorption plant, with its atmospheric cooling, is the least efficient.

The refrigeration unit supplements the absorption plant in still others ways that are important although not so generally appreciated. First, the fat oil entering the plant exchangers on its way to the preheater is proportionally lower in temperature as a result of refrigeration. This increases the mean temperature difference within the plant oil to oil exchangers and lowers the lean oil temperatures to the plant coils. As a result these coils are required to extract less heat and a closer approach of the lean oil to the water temperature is realized. This reduced lean oil temperature may be very appreciable in plants that are overloaded as is often the case when new refrigeration units are to be installed. On the other hand we have found relatively small increases in the heat load of the oil preheaters to the still.

Also the residual dry gas content, that is due to the vapor pressure of the light fractions in the lean oil, is reduced[3]. With the lowered oil temperature and corresponding drop in vapor pressure, there is a smaller loss of gasoline in the dry gas. This same factor would allow the use of a lighter mol weight absorption oil and resulting increased absorption efficiency, for complete stripping in the plant still is not as essential.

Still another advantage of refrigeration results from the lowered dewpoint of the dry gas and the reduced water vapor content. As a result there is usually no condensation in the dry gas fuel lines and this allows better performance through decreased pressure drops and reduced corrosion problems.

Another benefit lies in the fact that propane liquid can easily be made available for other services. These may vary from laboratory refrigeration, to air conditioning, to overhead condensation in a stabilizing column, or to wet gas cooling. Wet gas cooling is not too important in a low pressure plant because higher exchange rates can be obtained on the oil side and it is generally economic to take the full subcooling at this point; however, for maximum refrigeration wet gas cooling is definitely economic.

The process design of a refrigeration plant is fundamentally very simple. By the use of some practical data the operating conditions in a propane refrigeration plant can be found to a degree of accuracy well within the range of the basic assumptions of future operating conditions in the plant. We also believe that any natural gasoline plant can procure a satisfactory propane refrigerant from their plant.

When appreciable amounts of ethane and lighter contaminants are in the feed to the refrigeration system it is advisable to vent sufficient vapor from the condenser accumulator to bring the refrigerant down to a point of reasonable purity. This venting, or bleeding, is sug-

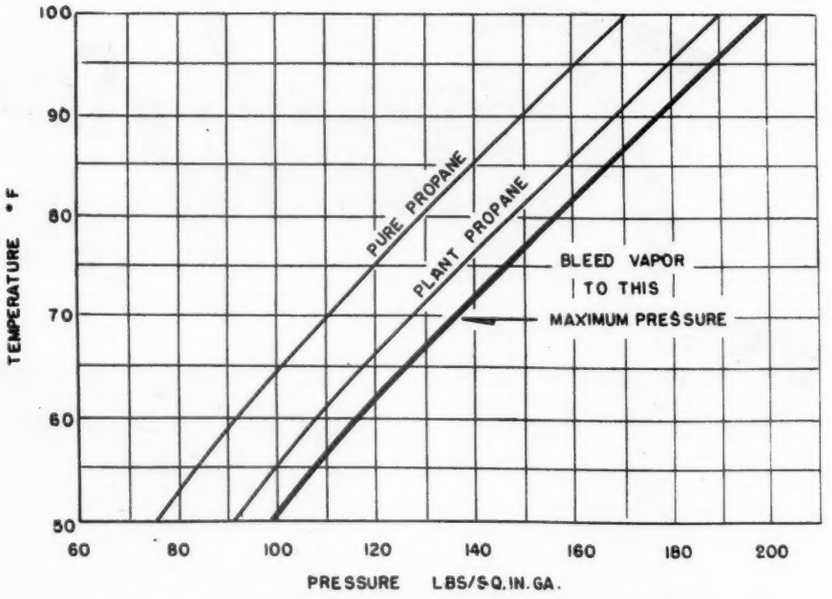

FIG. 2. CONDENSER, PRESSURE-TEMPERATURE CURVES.

TABLE 1—Propane analysis.

	A	B	K	D	E	F
Analysis, mol per cent						
Carbon dioxide	2.10	0.30	7.00	0.00	0.15	0.10
Methane	7.35	0.51	14.41	0.00	0.19	Trace
Ethane	7.69	2.88	2.67	0.04	2.33	1.23
Propane	82.70	95.95	0.86	98.54	96.95	98.30
Isobutane	0.16	0.36	0.44	1.03	0.38	0.37
Normal butane	0.00	0.00		0.39	0.00	Trace
Total	100.00	100.00		100.00	100.00	100.00
Specific gravity	1.421	1.531		1.551		

Remarks:
A—Condenser accumulator vapor, 172 lb. per sq. in. abs. and 79 °F.
B—Condenser accumulator liquid, 172 lb. per sq. in. abs. and 79 °F.
Plant propane before any bleeding—vapors to compressor.
K—Equilibrium constants, A/B.
D—Liquid in chiller—lube oil removed.
E—Condenser accumulator liquid, 162 lb. per sq. in. abs. and 79 °F.
Plant propane after bleeding approximately 10 per cent off B.
F—Plant propane from Signal Hill plant.
Specific gravity taken by Edwards Balance.
A to D samples procured at Huntington Beach before bleeding and E after bleeding.

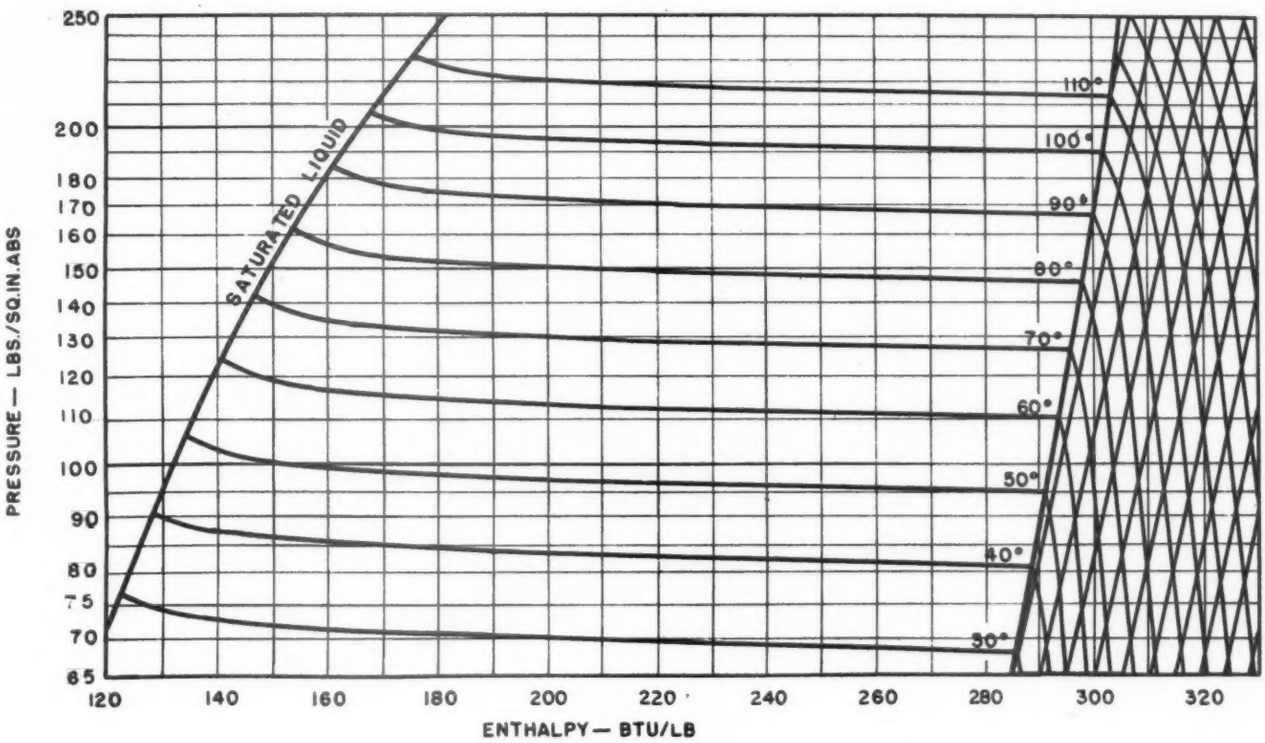

FIG. 3. MOLLIER DIAGRAM—"PLANT PROPANE."

gested in order to reduce the working pressures as well as the compressor horsepower. By limiting the probable discharge pressure the compressor cylinder can be rated for greater capacity. As the vapor to be bled is at the bubble point, it can be shown that relatively small quantities of vapor need be removed, with the best results obtained by bleeding this equilibrium vapor slowly (see actual analysis data in Table 1). For any temperature, vapor should be bled until the pressure is reduced to its allowable maximum (Fig. 2).

We call the propane refrigerant that reaches this vapor pressure limitation a "plant propane." This is the type of material under consideration in this paper. Unless the propane feed is consistently very pure, the plant propane should represent an average propane refrigerant.

Another point that is important in considering the use of plant propane is the fact that the light ends in this refrigerant are flashed upon expansion into the chilling unit at a greater rate than the propane itself. The bulk of the propane requires additional heat before flashing into the vapor phase. As a result, there is a greater proportional circulation of these light ends than there is of the pure propane In actual operation the analysis that is obtained at the intake to the compressors will show more of these light fractions than will be in the average propane in the chillers or in the system (Table 1). The extent of this condition is dependent upon the relative volume of propane in comparison with the vapor space in the same system and to the rate of circulation of the refrigerant. A large system and a light load could easily result in a circulation of much higher percentages of light ends than would be obtained at high circulation rates. The analysis we have used for plant propane takes into consideration the effect of the average rate of the circulation of these light ends and can be used for typical operations without unreasonable errors.

From these analyses, previous curves and data, a practical Mollier diagram has been developed (Fig. 3) that has been adjusted for actual operating values. This enthalpy chart shows the amount of heat in a pound of the plant propane plotted against pressures, with lines of constant temperatures shown between the lines of saturated liquid and saturated vapor. These have been corrected for the light ends in the plant propane mixture so that they follow a curve of boiling points between the saturated liquid and vapor limits. From this diagram it is possible to determine the relative amount of heat and the pressures and temperatures that can be expected at any point in the operation. The diagram will show the amount of heat

FIG. 4. TYPICAL FLOW SHEET.

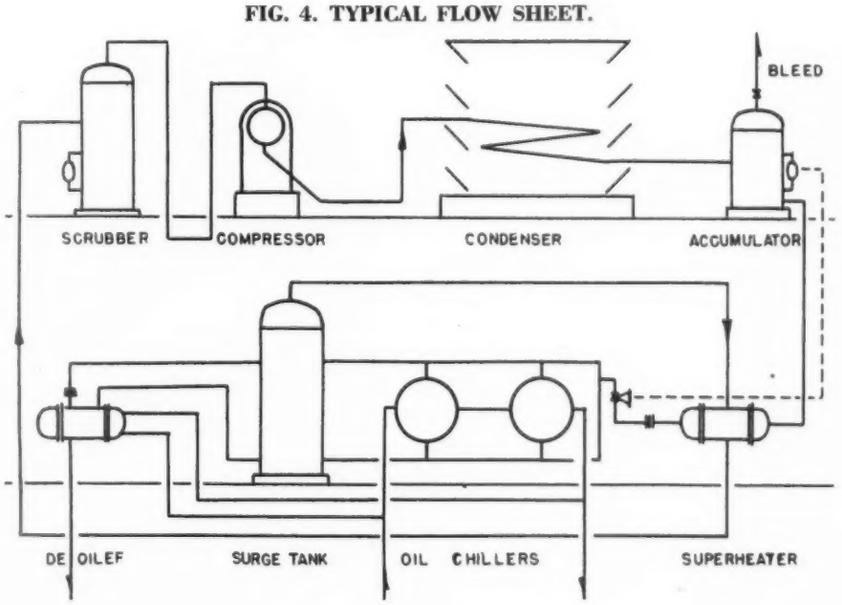

FIG. 5. SIGNAL HILL REFRIGERATION UNIT. From right to left the units are: Deoiler, raw gasoline chiller, propane surge tank, and oil chillers.

to be removed in the condensers, the effective cooling available in the chillers, the theoretical horsepower of compression, and many more important values. In fact, it will be the engineer's "bible."

We are including a typical flow diagram for a refrigeration cycle on lean oil subcooling (Fig. 4). This is offered as a guide to the general nonmenclature and as a base for more detailed discussion on the design of various units. This flow diagram is not submitted with any recommendation that this arrangement is preferable to others. It is only one of several. For example, our condensers are fabricated pipe coils but actually open sections or a closed condenser would be just as suitable. Also, the run-down accumulator can be designed for greater capacity and allowed to take any fluctuations in the liquid propane in the system. In such a condition the level control would be on the chiller unit instead of the accumulator. It is important to study the condenser under conditions of poorest cooling to determine the value of added surface against the horsepower of compression. The Mollier diagram will show the temperature-pressure relationship in the condensers and the special curve (Fig. 2) should show these values even more clearly. This change in pressure with the condenser temperature must be used in determining the relative values of added surface and additional compressor capacity.

Oil chillers are generally constructed in one of two types. First, a chiller without any vapor space in it that operates in conjunction with a surge tank. Second, a type with a vapor space that allows a level to be maintained within the unit. In either case the size of the chiller should be balanced against the compressor capacity, for within reasonable economic limits the same cooling can be effected by either means.

The lubricating oil from the compressor cylinders must be removed from the system before its volume builds up to the point that temperatures are affected or the liquid begins foaming. It is not felt to be economic to take any steps to remove the oil from the vapor at the compressor discharge because sufficient oil will probably get by and into the liquid propane to require its removal at this point. Actually a pure mineral lubricating oil offers no operating problem and a deoiler can easily be installed to accomplish its removal before any excessive concentration is possible. A side stream of the oil or other material to be cooled may be used for heating, and as the cooling effect of the propane may be utilized, there is no economic reason for not designing the deoiler rather liberally. It must be remembered too that the lube oil level must be kept low, for the foaming oil will otherwise carry over with the vapors.

It is felt that the utility and the design of the superheater deserves more consideration than is generally accorded it. This unit not only superheats the vapor and prevents condensation during compression but at the same time the subcooling increases the refrigeration in terms of horsepower per unit of cooling. With an impure, or plant propane, there is an additional advantage that can be realized from this subcooling. A study of the enthalpy chart will show that subcooling the liquid will reduce the quantity of flash upon expansion and at the same time will also reduce the flash temperature of the plant propane. If the chillers are designed to take advantage of this reduced temperature, and the increased temperature difference that can result, greater refrigeration can be obtained without any change in operating pressures. This will increase the net refrigeration and offers some very interesting economic possibilities, especially if the available horsepower assigned to this service is limited.

We believe that the complete unit should be designed for 250 lb. per sq. in. or the equivalent working pressure required for plant propane storage. Safety valve will be set to work at this pressure but except for fire they should never operate. With this allowable working pressure even the engines can be shut down without the necessity of releasing any of the propane from the system. The knowledge that the failure of any of the controls, or of the compressors, cannot cause a hazardous condition to materialize, allows a very healthy

FIG. 6. HUNTINGTON BEACH OIL CHILLERS. The 39-in. by 65-ft. unit at left is the final oil chiller in series with the two 25-in. by 65-ft. chillers on the right. Deoiler, superheater and scrubber are between chiller units.

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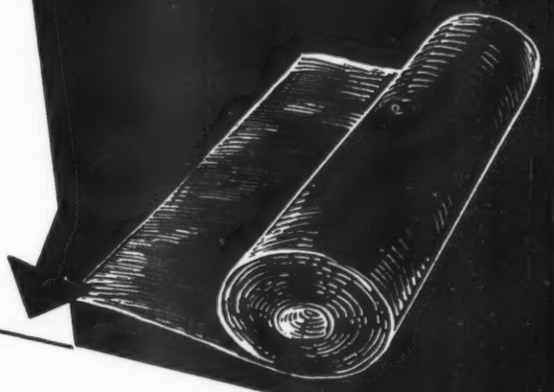

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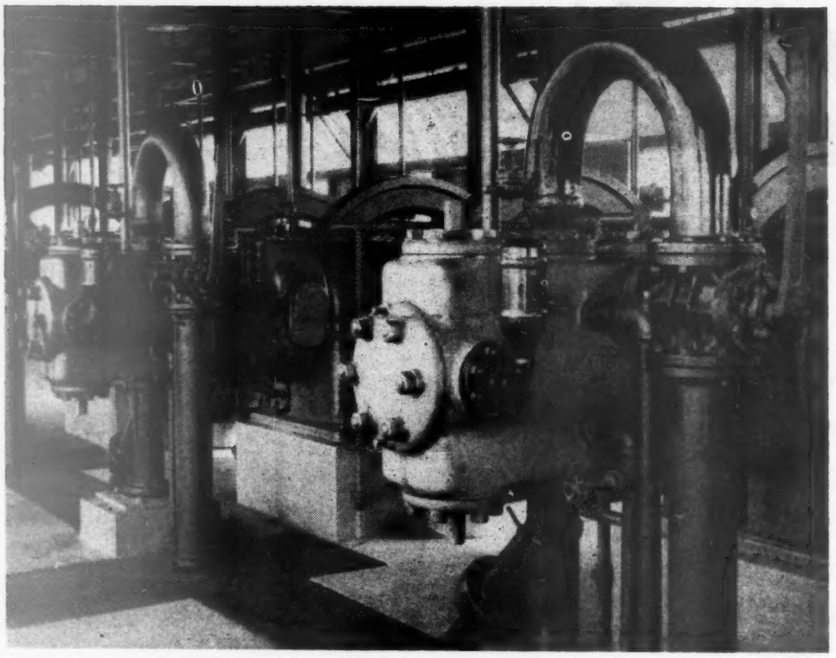

FIG. 7. HUNTINGTON BEACH PROPANE COMPRESSORS.

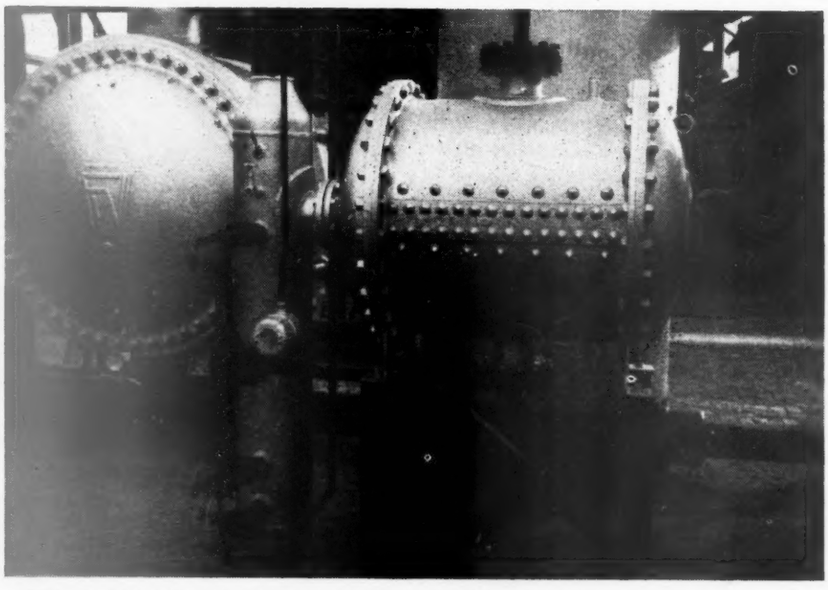

FIG. 8. SIGNAL HILL SUPERCHARGER AND SCRUBBER. The surge tank actually serves as a scrubber in this plant so that this unit serves as a means of installing a float and the magneto ground.

feeling of security on the part of all concerned. The cost of this added safety is nominal.

Propane refrigeration units have been added to two of the Signal Oil and Gas Company's low pressure absorption plants during the last year. At Signal Hill this allowed one plant to handle efficiently the wet gas previously treated in two plants. At Huntington Beach this addition was required to allow the plant to maintain its efficiency with the increased volumes of wet gas to be processed. The two units are naturally somewhat similar in their flow (Fig. 4) but differ considerably in their construction, especially in the case of the oil chillers (Figs. 5 and 6). Both plants have chillers on the total plant production as it is being pumped into the raw feed tank for the stabilizer. In addition, the Huntington Beach plant has a chiller on the natural gasoline and uncondensed vapors from the still run down condensers (Fig. 9).

Both plants better their estimated performance and have provided no unforeseen operating problem or hazard. In fact, the only unusual condition that we have had in a year of operation was the result of the failure of the air supply to the level control on the accumulator at Huntington Beach. This allowed the motor valve controlling the expansion of the liquid into the chillers to stand wide open and allowed all the liquid and a relatively small quantity of the vapors to pass into the chiller. The result was a small increase in the vapor load to the compressors and a decrease in the compressor discharge pressure of a few pounds, for full condensation was not required. The higher propane pressure in the chillers raised the oil temperature a few degrees but not enough to upset the plant operation and no hazard resulted from this failure.

A set of operating and performance data for both plants in included (Table 2). In general these are in good agreement with the Mollier diagram. For further comparison a set of the enthalpy data for Huntington Beach is given:

Compression	
Inlet vapor, 94 lb. abs. and 61°F.	296 B.t.u. per lb.
Discharge, 174 lb. abs. and 125°F.	309 B.t.u. per lb.
Work of compression	—15 B.t.u. per lb.
Condensation	
Inlet, 173 lb. abs. and 117°F.	313 B.t.u. per lb.
Oulet, 171 lb. abs. and 85°F.	157 B.t.u. per lb.
Heat of condensation	156 B.t.u. per lb.
Superheater	
Liquid in, 171 lb. abs. and 85°F.	157 B.t.u. per lb.
Liquid out, sat. liquid and 80°F.	153 B.t.u. per lb.
Subcooling	4 B.t.u. per lb.
Refrigeration	
Liquid in, 98 lb. abs. and 48°F.	153 B.t.u. per lb.
Vapor out, 98 lb. abs. and 53°F.	292 B.t.u. per lb.
Net refrigeration	—139 B.t.u. per lb.

The data taken from the Mollier diagram agree with the actual test data very closely except for the compressor performance. In this case the Mollier diagram gives a 108°F. discharge temperature whereas it was actually 125°F. Also, the minus 15 B.t.u. per lb. for the theoretical work of compression is too low a value. Both differences are due primarily to the fact that our intake and discharge pressures are from pipe line connections. Actually the pressure losses through the compressor valves will result in a lower intake and a higher discharge pressure within the cylinder and therefore a greater ratio of compression and increased theoretical horsepower. As the ratios of compression for this work are generally about 2.0 or less, a small change in either pressure can result in a relatively large percentage in-

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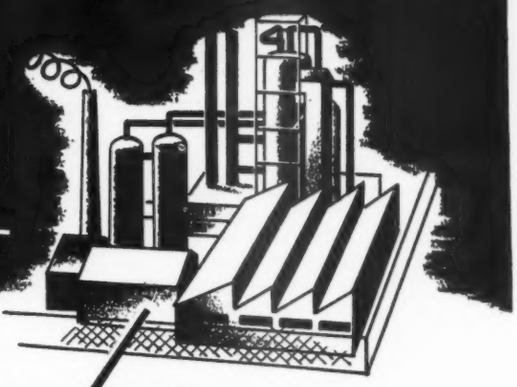

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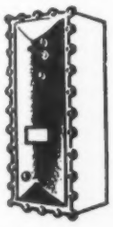

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crease in horsepower. Also, the jacket cooling water is generally warmer than the propane to the cylinder and therefore gives up heat in the cylinder and heats rather than cools the vapor.

This difference in readings is typical and must be considered in any design before any value is accepted for the compressor horsepower. The actual horsepower required to compress propane is less than generally required for natural gases due to the relatively low ratio of specific heats (1.17). For this reason one of the more generally accepted curves of horspower per 1,000,000 cu. ft. per day for different ratios of compression, can be used[4] or any other curve or empirical data with which one is familiar and can interpret for this type of service.

Continuing with our discussion of actual operating and design data, there are several other points of interest in connection with the compressors. These include the use of a non-return or a check valve, which should be installed on the discharge of the compressor. We also feel it is better to install the compressor intake line so that it rises and makes a 180-deg. bend with the shut-off valve on the riser. This reduces the possibility of liquid accumulating above the intake valve during periods when the compressor is down (Fig. 7). In cases where the shut-off valve must be placed in a position that would allow the accumulation of liquid between the valve and the header it is very important to install a bleeder that will permit complete drainage of any liquid before the engine is started.

We believe that there are a number of advantages favoring the use of a slightly oversize compressor cylinder and then bringing it down to the desired operating range by the use of clearance bottles. The most important of these advantages is the flexibility that is offered. This not only allows the correct capacity for the calculated design conditions to be effected but will allow a clearance adjustment to be made at any time to meet further or changed operations over a wide range of conditions. Also, clearance pockets have less effect on the cylinder capacity at low compression ratios such as exist under the higher intake pressures and higher loads. For this reason when the atmospheric cooling is the poorest and the chillers are producing the greatest cooling effect, the compressor cylinders are handling this increased volume of propane with the highest relative efficiency. This is an ideal situation, for it allows the greatest load to result at those times when the value is greatest and higher horsepower can be justified.

The condensers in our plants are pipe coils designed for the necessary drainage to handle full condensation without unnecessary pressure drop. It can be seen from the Mollier diagram that there will be a relatively large mean temperature difference (MTD) between the cooling water and the propane except for the last 10 per cent, or less when the plant propane temperature curve swings up as a result of the light hydrocarbons, which reduces the temperature difference very materially. Actual test data indicate that half the heat of condensation was done in the first 30 per cent and two-thirds in 50 per cent of the coil.

TABLE 2—Operating data.

	Signal Hill	Huntington Beach
General		
Oil rate, 1000 gal. per day	585	1,110
Natural gasoline, gal. per day	28,500	45,500
Propane refrigerant		
M. cu. ft. per day	3,260	5,520
Lb. per hr.	15,800	27,000
Gal. per min.	62	105
Condensers		
Surface (O.D.), sq. ft.	3,670	5,810
Pressure: in	152	173
out	148	171
Temperature: in	106	117
out	76	85
Superheater		
Surface (O.D.), sq. ft.	385	250
Temperatures		
Vapor: in	46	53
out	58	60
Liquid: in	76	85
out	67	80
Oil chillers		
Surface (O.D.), sq. ft.	2,660	7,650
Propane, gal per min.		93
Pressures		
Oil: in	92	72
out	84	65
Chiller	88	98
Temperatures		
Oil: in	74	73
out	49	53
Propane: Flash		48
Final		53
Surge	46	
Gasoline chillers		
Surface, sq. ft.	450	450
Pressures		
Gasoline: in	105	105
Propane	88	105
Temperatures		
Gasoline: in	87	82
out	63	60
Propane	46	55
Compressors		
Pressures		
Intake	87	94
Discharge	152	174
Compression ratio	1.75	1.85
Temperatures		
Intake	58	61
Discharge	113	125
Engine cooling water	110	110

Remarks—One-third additional compressor capacity is being installed at Huntington Beach.

Pressure given in lb. per sq. in. abs. and temperatures in °F.

FIG. 9. HUNTINGTON BEACH GASOLINE CHILLERS. Note separate surge tank and level control for semi-independent operation.

In the Huntington Beach plant the oil chiller was designed to utilize the range in boiling temperatures available in a plant propane at a constant pressure. The oil chillers at this plant consist of one 39-in. by 65-ft. and two parallel 25-in. by 65-ft. long units in series flow. The propane is expanded into one end of the 39-in. chiller and travels the length of this unit before it overflows a weir that maintains the level of the propane and flows into the other chiller. The chillers are piped for counterflow. The propane temperature increases about 5°F. between the point of expansion and the end of the chillers. These changing temperatures can be checked on the Mollier diagram and are obviously worth consideration as a means of increasing the MTD and therefore the actual cooling. You will note in the operating data that our final oil temperature is 53°F., which is the same as the final propane temperature. The initial, or flash, temperature of the propane is 48°F.

These chillers at Huntington Beach make use of standard 1-in. pipe for tubes and were fabricated in place.

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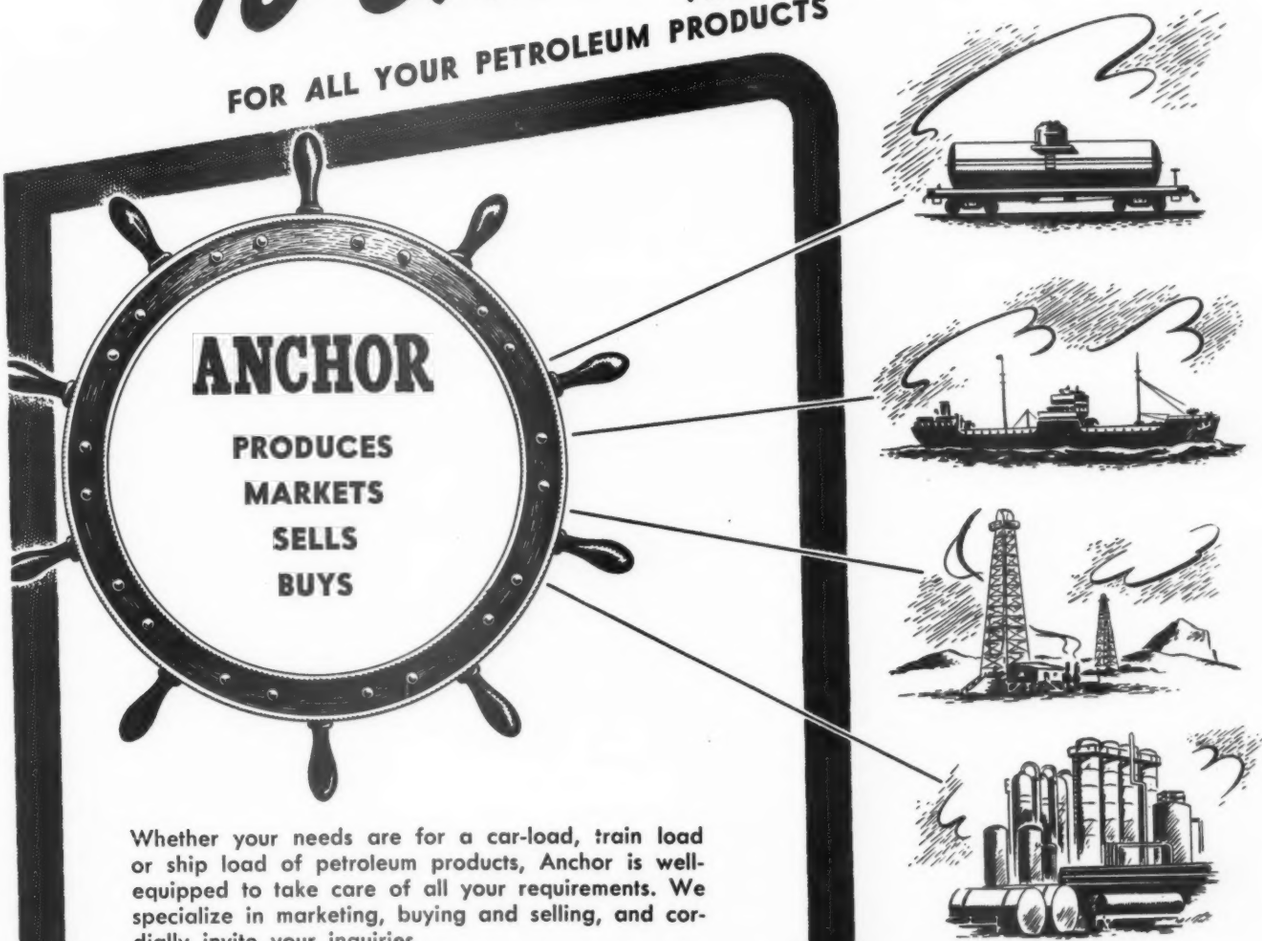

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These pipe tubes were placed in the lower two-thirds of the shell, which leaves the top third for vapor space. We also utilize these oil chillers for the small amount of working storage that is necessary to avoid adding propane more often than necessary. The minimum level of propane for efficient operation is indicated by a superheating of the vapors as a result of the direct contact with the tubes as the level drops too low. This minimum efficient level can be determined definitely if thermometers are installed in both liquid and vapors. This will then give a reliable minimum level that can be indicated by a gage glass reading during normal operation.

At Signal Hill, commercial exchange units were installed. They have performed as well as could be desired; however, with this type of design, which is very similar to that shown in the flow diagram, there is no means of taking efficient advantage of the lower flash temperature and slightly greater surface is required for the same refrigeration. The economic choice between these two types of cooler will depend upon individual conditions and this can be decided after considering both possibilities.

The deoiler must obtain its feed from the point where there will normally be the greatest concentration of lubricating oil in the system. At Signal Hill where the propane is in constant circulation the supply is taken from the surge tank. At Huntington Beach the propane enters at the end of a long horizontal chilling unit and flows lengthwise through this unit. For this reason the lubricating oil will become concentrated at the end of the unit and the feed for the deoiler is taken from this point of greatest concentration. In this plant where the design allows the lubricating oil to concentrate within the system, the problem of removing the oil is obviously simplified.

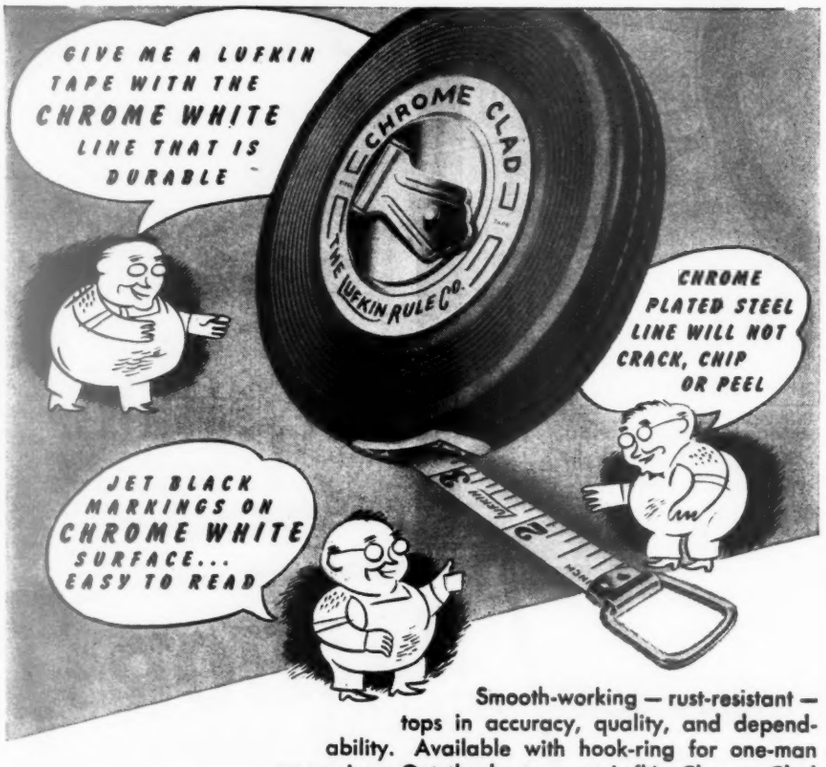
To further describe the units, at Huntington Beach we have chillers on both our rundown gasoline and uncondensed vapors and on the raw production into the stabilizer feed tank (Fig. 9). These units are independent of our oil chillers and are situated in another area of the plant. Both are converted exchanger units and are connected top and bottom to a propane surge tank. A level control on the surge tank maintains an independent level in this tank. A small drain line to the deoiler is used to remove the lubricating oil that concentrates in this unit.

The chiller unit on the rundown liquid and uncondensed vapors from the still condenser is used to control the volume of vapors that must be handled by the vapor compressor. The other chiller unit is on the plant production to the stabilizer feed tank and in this case the cooling permits a lower pressure for separation of the excess light fractions. This lower temperature allows a better separation of the light hydrocarbons because of their relatively smaller reduction in vapor pressure at these colder temperatures[5]. The amount of cooling on each chiller is regulated manually by an occasional adjustment of the valve on the vapor line out of the exchanger and into the surge tank. It has been found that very even control can be obtained by this means and the back pressure valves or controllers were not necessary. The addition of these two chillers allowed us to continue with the same vapor compressor as existed in the plant before the addition of the refrigeration unit and the resulting increased extraction of light hydrocarbons. It was found that the refrigeration horsepower necessary to reduce the vapor volume and lower the discharge pressure is approximately 60 per cent of the horsepower that would have been required to handle the additional vapors without this refrigeration. The additional 40 per cent of the horsepower is available for additional refrigration. There has been no problem in connection with this operation.

● **Conclusion.** In conclusion, we are firmly convinced that refrigeration can be justified in a new low pressure absorption plant in cases where the future maximum volumes of wet gas are known within reasonably close limits, or where the atmospheric temperatures and humidity are too high to allow efficient atmospheric cooling. We realize that refrigeration is also justified in many high pressure operations but we have limited this paper to low pressure absorption where the advantages to be gained are probably more pronounced, due primarily to the fact that a greater cooling range is possible without danger of hydrate or ice formations.

The use of refrigeration is also felt to be the simplest, cheapest, and most economical means of procuring additional plant capacity in existing plants. Experience has shown that the problems of operating and maintaining a refrigeration plant are extremely few and of minor importance. It also indicates that no unusual hazards result from the use of propane refrigerant. It is believed that practically any plant can develop a supply of propane at very small cost that will prove acceptable as a refrigerant for this type of operation. Although papers have been presented in the past dealing with the advantages of propane refrigeration, their value has apparently not been fully appreciated. It is hoped that the presentation of this information on a practical rather than a more theoretical basis will prove the key necessary to open the door to a more general acceptance of this type of installation, which we feel to be justified on a practical and economical basis.

1. "Liquefaction and Regasification of Lighter Hydrocarbons," F. W. Laverty and W. C. Edmister, *Oil and Gas Journal*, September, 1941.
2. "Increasing Propane Recovery in Existing Natural Gasoline Absorption Plants," F. W. Bell, *Petroleum Refiner*, June, 1945.
3. "Theoretical Analysis of Absorption Process," Alois Kremser, *National Petroleum News*, May 21, 1930.
4. *Gas Engineers Handbook*, p. 766.
5. "Increasing Isobutane Production in Natural Gasoline Plants," G. N. Hile, *California Oil World*, November, 1942. ★ ★ ★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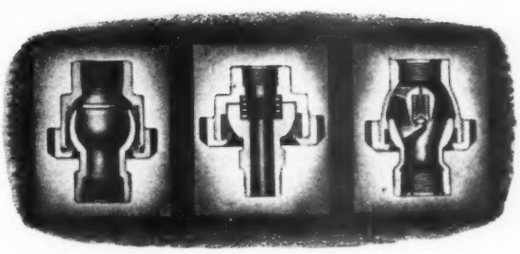

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Utilization of Electrical Equipment

ROY B. BRYANT, *Electrical Engineer,* General Petroleum Company

F. M. DOREY, *Service Engineer,* Petroleum Industry, General Electric Co.

● **General problems.** Electricity today is being used to a greater extent in oil refineries than ever before, and is constantly playing an increasingly important part. More and more attention is being placed on the electrical layout and planning, many problems of which are special to the oil refining industry. California state law demands the use of specially designed explosion-proof wiring and electrical equipment in the refining areas and in many locations it also needs to be corrosion resistant. These special designs cost considerably more than standard electrical equipment. Furthermore, the operation of explosion-resistant electrical equipment in such locations is complicated in case of trouble, as it cannot be tested until it has been removed from the area. Considerable quantities of abrasive dust from processes further increase the duty imposed on the successful operation and maintenance of electrical equipment.

EXCLUSIVE

The growing amount of electrical power used in present day refineries can be appreciated when it is realized that not too many years ago 500 or 600 hp. was a good refinery load and today refineries run up as high as 30,000 hp. connected electrical load. The greatly increased power capacities give rise to high short circuit currents. The effect of these on circuit breaker capacities, voltage regulation problems, power factor, and relaying problems must be carefully considered by the electrical engineer. In many refinery operations, shutdowns are extremely costly and a single motor or circuit failure will cause a refinery unit shutdown of several days with the accompanying loss of money. The electrical engineer, in selecting the equipment and laying out the design, must plan carefully to keep such emergency shutdowns to a minimum, and in addition, arrange the installation so that any failures of equipment or circuits can be quickly and safely repaired.

There has developed today two distinct schools of thought with respect to the location of control and switchgear in oil refineries. One is to use explosion-proof equipment and install it inside battery limits, and the other is to use standard electrical equipment and keep it outside of battery limits.

● **Explosion-proof or normal wiring.** The General Petroleum Company at its Torrance Refinery has had remarkable success in solving these problems. This refinery was originally designed in 1929 and today makes all types of fuels and gasolines up to 100-octane rating. The electrical layout and design are unique in several features. The plant was originally built as a large distillation unit and was started from scratch at the present location. The installation was planned and coordinated as a unit. There are more than 900 acres so that there was ample room to lay out the equipment without crowding.

R. B. Bryant

F. M. Dorey

It was decided to divide the refinery into refining and utility areas. Roads were decided to be the line of demarkation and all actual refining processes were installed on one side of the road. The refining area contains only such electrical equipment as is absolutely necessary to install in it, namely, lights, the motors themselves, and the pushbutton control for starting and stopping them. All motors and pushbuttons in this area are, of course, explosion-proof.

The other side of the road was established as a normal area. This contains boilers, utilities, shops, electrical switch houses, etc. As the switch houses are situated out of the refining area, the electrical equipment is of standard general purpose design. The switch houses contain the control for all motors

FIG. 1. Three totally enclosed fan-cooled motors driving pumps situated in the refining area. Note pushbutton control station on the post.

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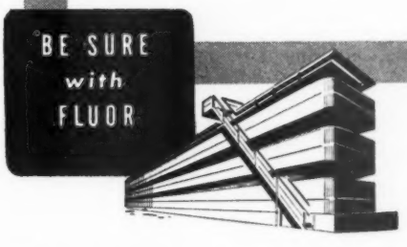

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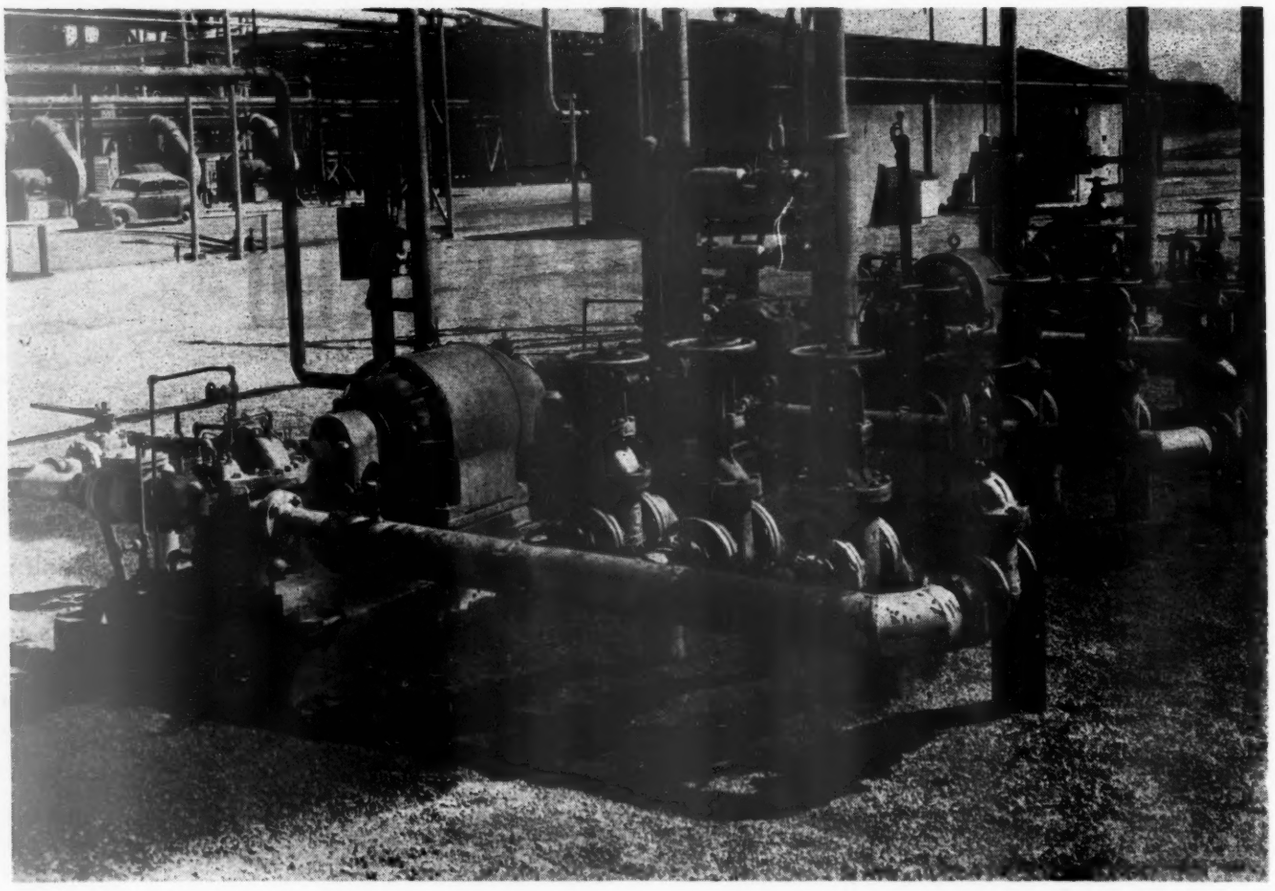

FIG. 2. Example of outdoor construction. Two motors driving charge pumps are automatically spared by turbine-driven pumps.

in the refining area and also contain switchgear, relays, capacitors, emergency power service, and lighting service. Since the original installation, other units have been added. The heat balance is worked out for each unit individually. Turbine drives are used to take care of the process steam requirements and the rest of the drives in each unit are electrical. This permits new units to be added as required without disturbing the heat balance of previously installed equipment and saves the installation cost of an expensive low pressure steam system. The overall layout of refining and normal areas allows changes and additions to be made without being concerned with electrical and other equipment because of the addition of some new equipment nearby. With the exception of the process control houses, no buildings house any equipment in the refinery area. All motors, pumps, etc., are mounted outdoors and are not manifolded or grouped together, as is customary in pump houses. Typical groups of motors are shown in Figs. 1, 2, and 3.

● **Switch houses and process control houses.** The newer switch houses and process control houses are of monolithic concrete construction without windows and are force ventilated and pressurized with filtered air. There are no inflammable materials such as oil or gas brought into the control houses. All metering and control is done by electrical or remote pneumatic systems. Thus, there is no possibility of a line springing a leak and permitting hazardous gases to get into the control house. All cables and conduits brought into the house are sealed off where they are brought in so that there is no possibility of escaping gases creeping down them and gaining entrance to the control houses. With this type of construction, it is practically impossible for control to be lost because of a fire in the process control room. It is permissible to use standard conduit construction without use of explosion resistant fittings. The saving in installed wiring and enclosure costs alone will largely pay for the remote pneumatic control system. The compressed air for the pneumatic control system is obtained from non-lubricated compressors and is ethylene-glycol scrubbed to a dew point of 10° F., thus making it perfectly free of water at operating temperatures.

It is possible to make the wiring explosion-proof, but it is impossible to purchase many types of instruments that do not present a hazard. Because the process control rooms are designed so that it is impossible to have a hazardous atmosphere inside the room, it is possible to work on this equipment at any time. This simplifies maintenance problems. It is practicable to use controls that are not of themselves explosion-resistant and also save on the cost of wiring.

In order to prevent sweating during shutdown in damp weather, the switch rooms are heated by fin type electric heaters thermostatically controlled. The temperature is maintained at 100° F. during shutdown. The process control houses are temperature controlled at all times.

● **Power distribution systems.** The refinery is fed by two 16.5kv, 3-phase, 50-cycle feeders from the Southern California Edison system. The two feeders are operated in parallel but one will carry all the load if the other fails. Fig. 4 shows a one line diagram of the power distribution system. The system was laid out in 1929 and resembles very closely the load center distribution systems that are being universally applied to industrial plants today. The radial distribution system feeds the 16.5-kv. voltage to separate switch house substations strategically situated with regard to refining units, throughout the normal area of the refinery, and the voltage is then stepped down to the operating voltages. There are 9 radial feeders and switch houses, which show that the power is fed at the higher voltage to the load centers where it is actually used, and then stepped down to the operating voltages. This accounts for a very appreciable saving in the size of copper that would be required if the power was transformed to a lower voltage at one location and then fed throughout the re-

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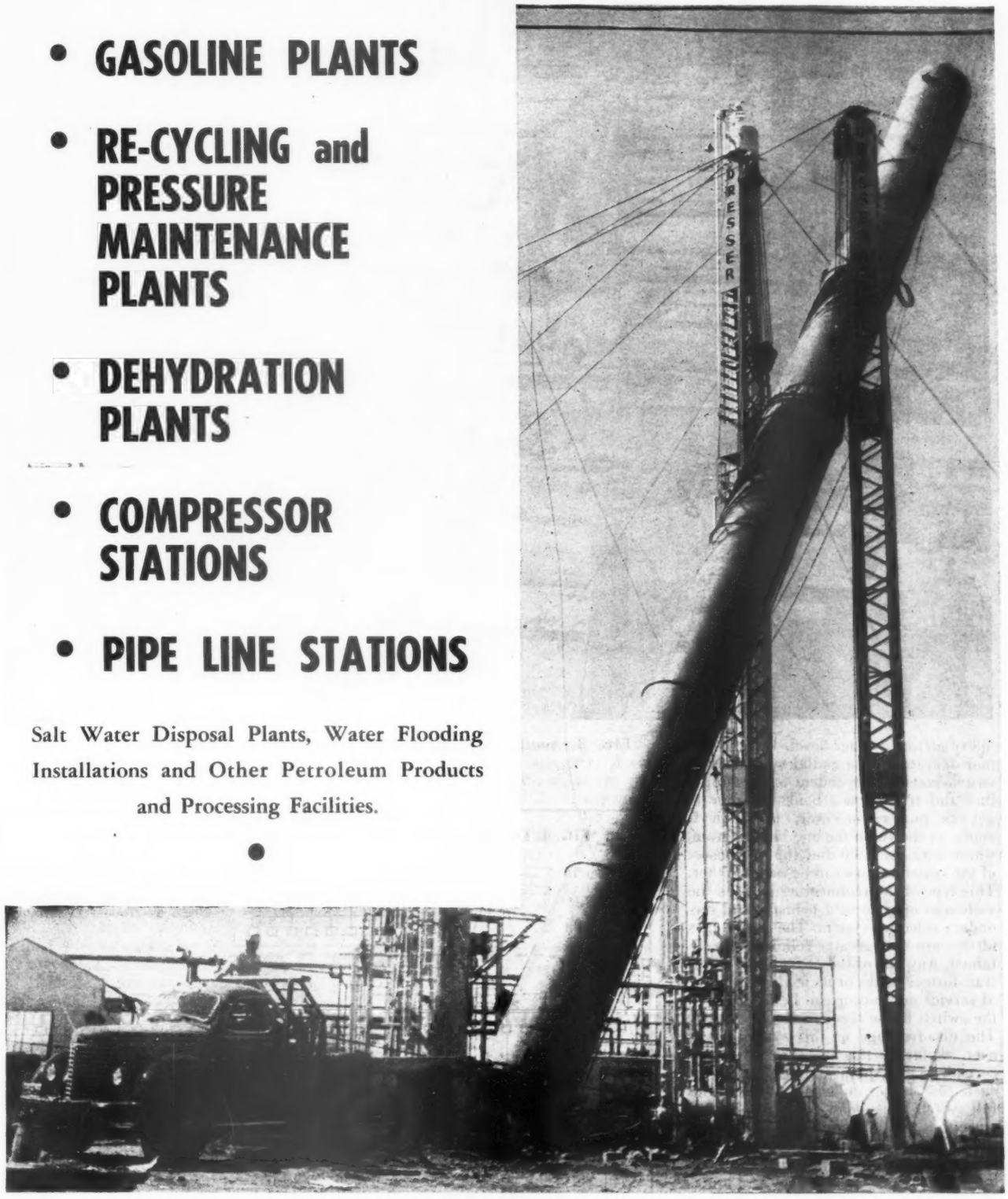

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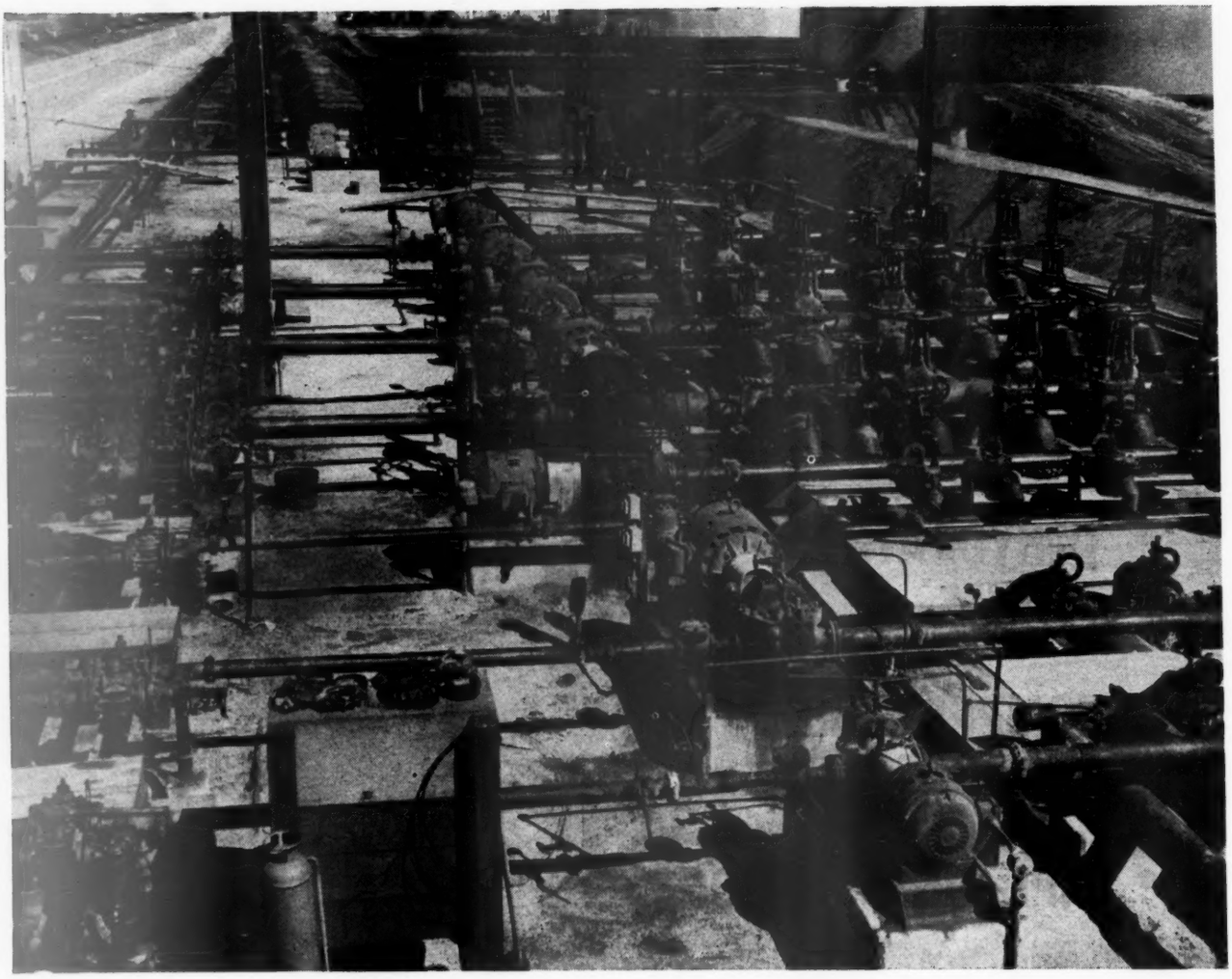
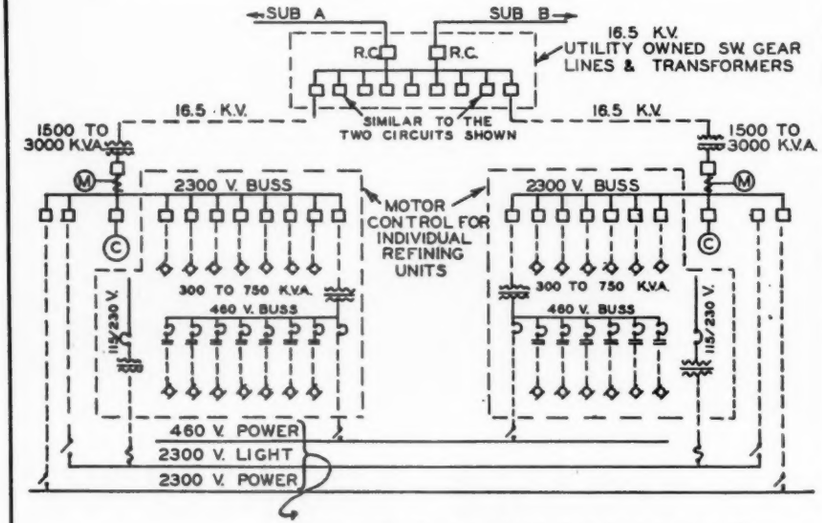


FIG. 3. Another typical group of motors—manifold and transfer pumps.

finery at that voltage level. During normal operation as a radial system, each switch house is dependent on its supply line and transformer bank in order to get its power; however, provision is made, as shown on the one line diagram, where both the 2300 and 460-volt busses of the switch houses can be tied together. This type of interconnection permits the system to operate as a primary and secondary selective system. The advantages of this are that greater reliability is obtained. Any one of the 16,500—2300-volt transformer banks or its feeder can go out of service and power can be fed back to the switch house through the tie busses. The disadvantage of this system, however, as far as this installation is concerned, is that the available capacity in each case is not sufficient to carry the full switch house load. When conditions permit, it is contemplated to install a full 2300-volt network that will allow failure of any transformer bank without interrupting the operation of any units. The short circuit kva. on the 16.5-kv. bus at the switch rack is 125,000 kva. The approximate short circuit kva. on one 2300-volt bus when operating as a radial system is 43,000 kva.

In order to keep the short circuit kva. to a minimum, each substation is operated separately, as explained in the operation of a straight radial system. Each

FIG. 4. DIAGRAM OF THE POWER DISTRIBUTION SYSTEM.



These sectionalized overhead plant feeders serve all utilities, boilers, water wells and treating, shops, office, laboratories, etc. Also provide lighting at each unit from a source other than its own power bank.

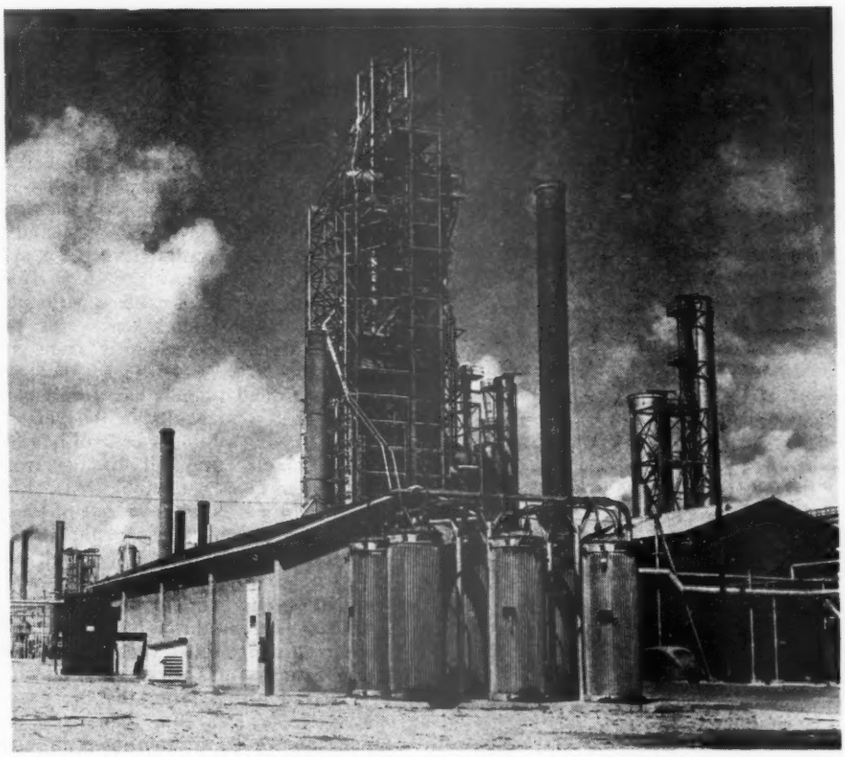


FIG. 5. Switch house with the 16.5/23-kv. transformer bank in the foreground; the 2300/460-volt, 3-phase transformer on the side. Other switch houses in background.

switch house is fed by oil filled 16,500—2300-volt transformers and each transformer bank is fed by an underground radial feeder. The incoming leads to the 16.5-kv. volt side of the transformer are underground lead cables and are wiped direct into the transformer connections and no bushings are used. Fig. 5 shows one of the switch houses. It has its transformer banks situated just outside. Fig. 4, in addition to showing the radial feeder diagram, also shows a one line diagram of the distribution circuits in 2 of the switch houses. All switch houses are essentially the same.The 2300-volt circuit from the transformer bank feeds directly the 2300-volt bus through lead cables wiped directly to the transformers. With this type of construction, there are no transformer bushings to clean. Secondary windings are brought directly to the main disconnects and the delta connection is closed at that point. A 2300/460 polyphase transformer bank feeds directly the 460-volt bus. As already pointed out, there are feeder ties to the plant overhead feeder system in order that the 2300 or 460-volt busses in any switch house may be used to energize the feeder system to which all plant utilities are connected. The 16,500—2300-volt transformer banks range in capacity from 1500 to 3000 kva. The 2300/460-volt transformer banks vary in size from 350 to 750 kva.

As originally installed, the power factor of the refinery was about 0.8. Practically all motor load in the refinery consists of induction motors operating continuously at close to full load. The power company schedule under which the refinery operates gives a bonus for improved power factor. A complete study was made of the operating conditions and capacitors were then installed on the 2300-volt bus in each switch house. A total of over 4200 kva. of capacitors has been installed up to the present time, and approximately 9½ per cent of the permissible 10 per cent power factor rebate is procured.

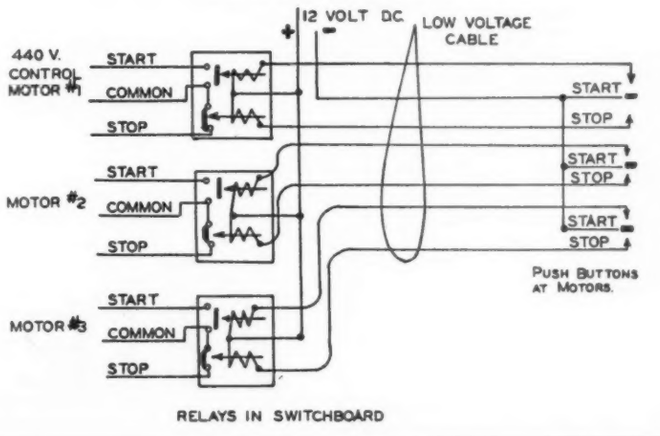
The Southern California Edison Company owns and maintains the 16.5-kv. substation, the radial underground cables, and the 16,500—2300-volt transformers. Power is metered on the 2300 volt side of each transformer bank. The power company checks all relays and circuit breakers on the 16.5-kv. system and cleans all the 16.5-kv. insulators.

● **Motors and control.** Motors of 50 hp. and over are normally operated on 2300 volts. The general practice in industrial plants is to keep all motors below 150 or 200 hp. at 440 volts, and to go to 2300-volt operation only in the larger sizes. There are two main reasons for this, one is that the cost of motors in the smaller sizes is more for 2300-volt ratings, and the other is that in going from 440 to 2300 volts, the copper size in the winding itself is decreased proportionately, and in ratings below 150 hp., its mechanical strength is somewhat questioned. In this particular installation, however, the 2300-volt motors are used in sizes above 50 hp., first to keep the 440 transformer bank and switchgear to an economical size as regards interrupting and current carrying capacity of the breakers involved, and second, to get away from the secondary transformer costs, excessive voltage drop, cable size and conduit costs, that would be encountered because of the long runs between the motors in the refining areas and the starters back in the switch houses. These runs are sometimes as much as 300 ft. The pushbutton control station and indicating lights are mounted in the refining area, and the control is placed in the switch houses. There are no fuses used anywhere in the lighting or 460-volt power circuits. All switching and protection is by means of air circuit breakers. This practice practically eliminates the possibility of single phase operation on any of the circuits and prevents motor burn-outs from that cause.

Very few synchronous motors are used, principally because of the expense and difficulty in getting 2-pole synchronous motors in explosion-proof designs. The present practice is to use induction motors and install capacitors in order to correct the power factor. This is the simplest and cheapest way to obtain the necessary correction.

All 460-volt motors and all 2300-volt motors are full voltage starting except

FIG. 6. SCHEMATIC WIRING DIAGRAM SHOWING PRINCIPLES OF 12-D-C. CONTROL SYSTEM.



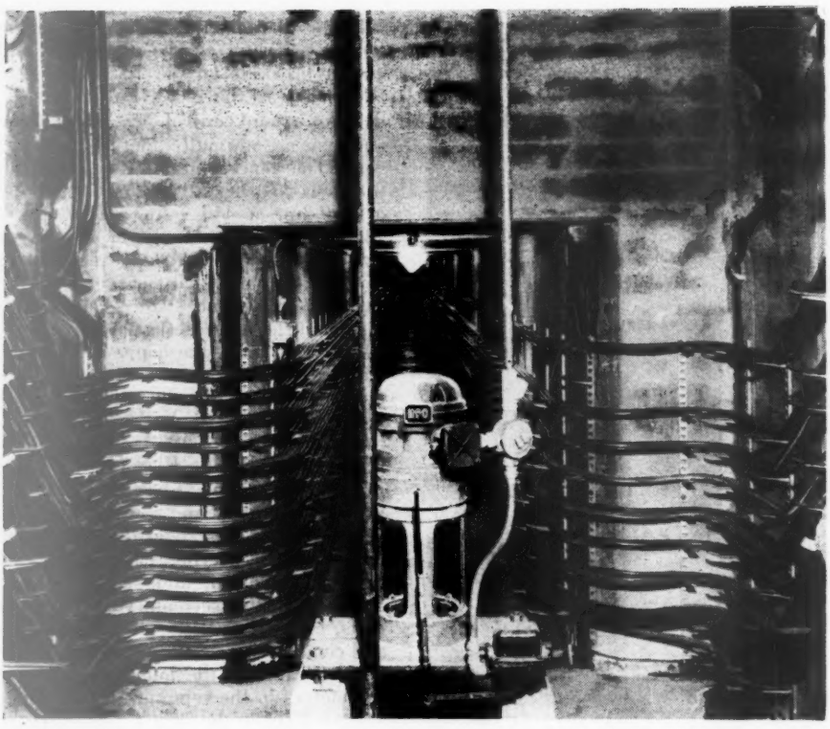


FIG. 7. One of the tunnels that runs from the switch houses to the refining area. The cable can be seen racked up on the sides. The motor in the foreground drives a sump-pump used to remove accumulated water.

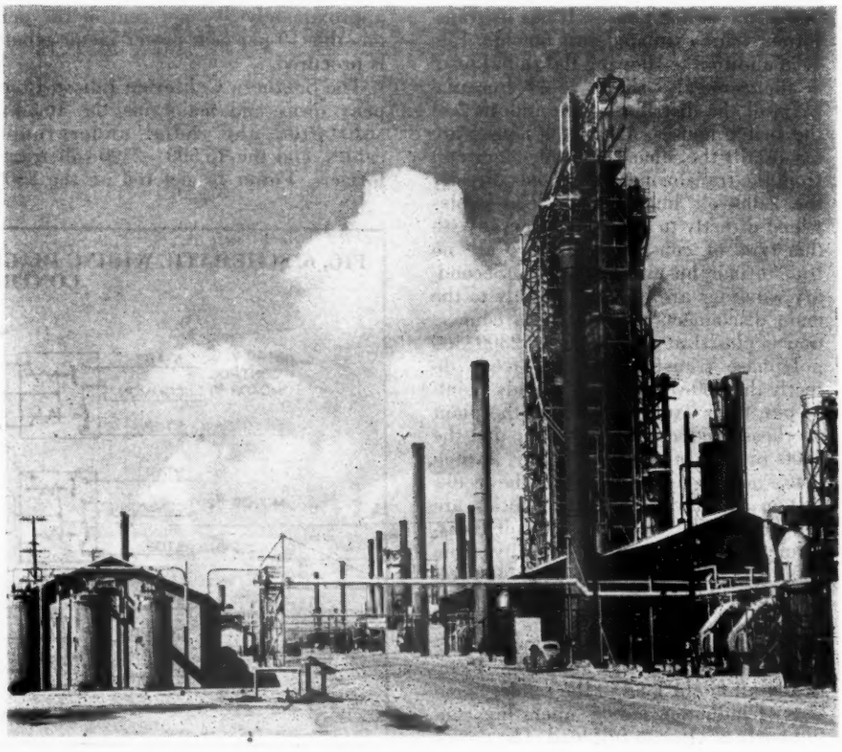
for a few applications where the starting conditions of the driven unit are such so as to make full voltage starting impractical. The starters for the 460-volt motors are type 1, general purpose magnetic starters. The 2300-volt starters use solenoid operated oil circuit breakers and use copper oxide rectifiers for supplying the d.c. for solenoid operation.

Drives for boiler feed pumps, cooling tower circulating pumps, and other essential operations have a steam turbine operated spare, and in the event of motor failure, the turbine will be up to speed in 9 or 10 sec. Each vital switch house has an emergency connection to a steam turbine driven alternator ranging in capacity from 75 to 135 kva. In the event of failure of normal power, the emergency alternator automatically starts up and takes over all lighting and instrumentation loads in approximately 20 sec.

● **Direct-current control system.** In order to facilitate the operation of the control and automatic turbine cutovers, a 12-volt d-c. control circuit is used. The sketch in Fig. 6 shows the principle that is followed. Two small relays are mounted near the motor starter. One with normally open contacts replaces the conventional start button and the other, with normally closed contacts, replaces the stop button. The 12-volt operating circuits for these relays are run into the pushbutton control stations near the motors. The principal advantage of this system is that one 12 or 24 conductor cable can be run in a single conduit to a group of motors at a distance from the switchboard, thus making it unnecessary to run a single conduit for each motor, as would have to be done to satisfy the California Industrial Accident Commission Code if 460 volts were run out to the pushbutton stations. It is also very simple to put in multiple start and stop stations, interlock circuits and pilot lights. This control circuit is operated from batteries and is independent of power supply failures. This low voltage system also eliminates the possibility of not being able to drop out the contactor because of capacity current between the control wires in long runs if a 460-volt a.c. were used. This system permits lower initial cost under the particular conditions of this refinery as the distances are long and involve multiple conductor cables. Actually it was found 12 or more motors justified this d-c. system on a strictly cost basis. This permits a large number of start and stop button and pilot lights, interlocks, etc., in the refinery locations and requires only a small space and a single conduit. A similar 12-volt d-c. system is used for alarms and signals. Telephone and fire alarm cables are looped between switch houses and enter the refinery areas independently from the switch houses.

Underground tunnels run from some switch houses to vaults in the various refining areas and under control houses. These tunnels carry all circuits from the switch houses to the areas. Fig. 7 is a picture looking down one of these tunnels from beneath one of the switch houses. It was taken from the vault underneath the switch house and shows an automatic sump-pump in the foreground. The cables extend through the vault and troughs directly into the equipment above. Some tunnels are pressurized with dry filtered air in order that no gases may possibly leak into them, and all tunnels and vaults are ventilated through stacks at the far end. Normal heating from the cables will establish thermal convection, which thoroughly ventilates the tunnel, duct and vault system with air from a safe source. The 2300-volt cables are racked up on top of one side of the tunnel with 460-volt circuits, 12-volt circuits, and lighting circuits racked

FIG. 8. The road divides the refinery and the normal areas. The refinery area is at right, normal at left.



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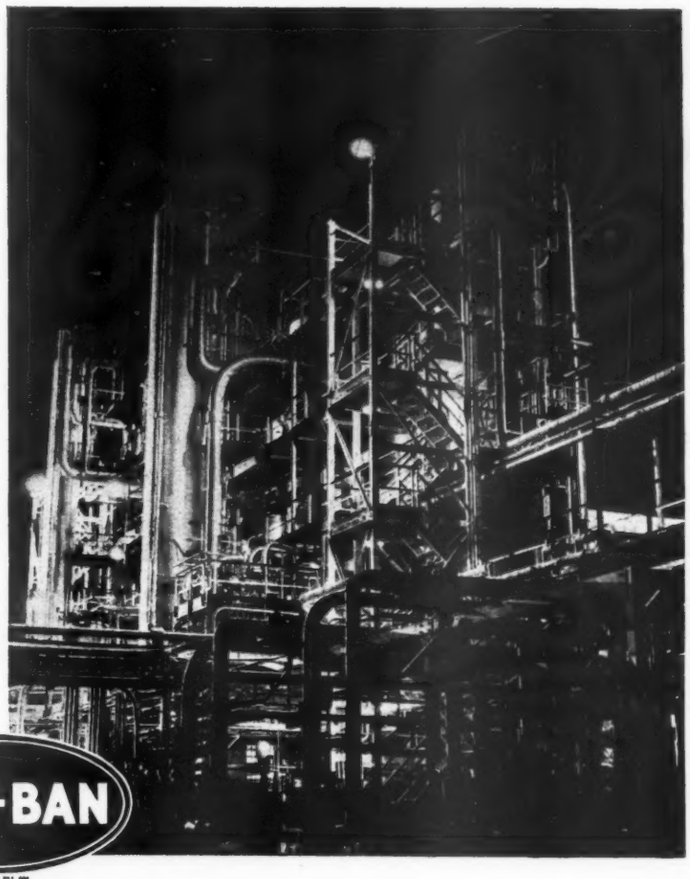

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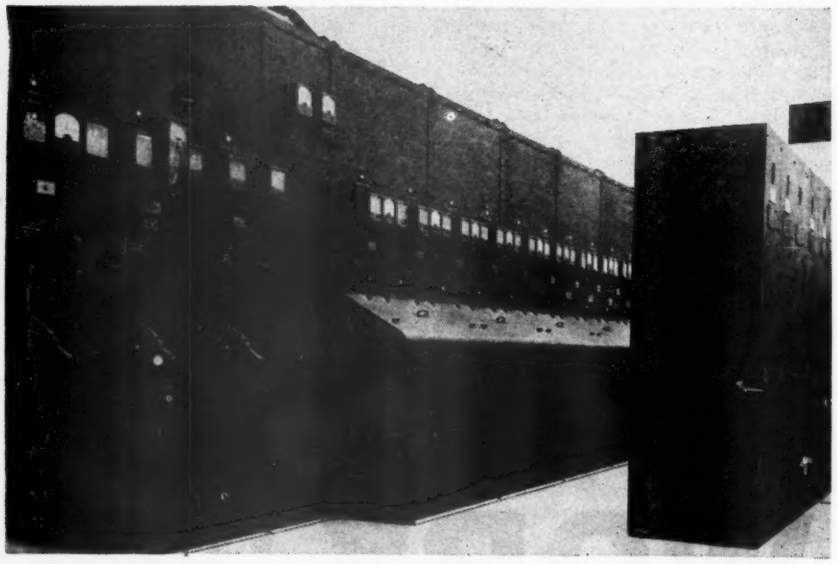

FIG. 9. General purpose switchgear is used in the switch houses. Feeder breakers are at left; solenoid-operated motor starter breakers in middle, and 460-volt starter and control board at right.

up beneath. On the other side of the tunnel, thermocouple leads, copper tubing for the remote pneumatic control system, etc., feed into the area from the control house. These leads are all tagged for quick identification. This has proved exceptionally helpful in quickly locating trouble and making immediate repairs. Installation time is quicker and the cost is cheaper because cables do not have to be individually pulled through conduit. In cases of fire or a small flash-back, this system saves times in getting back into operation, because it is merely necessary to pull the burned end of the cable back into the tunnel and splice it, and it is not necessary to pull in a complete new cable through a long run of conduit, which would have to be done if it were not for the tunnel. The tunnels are kept cool and afford much better cooling for the cables than would be obtained if they were in conduit.

● **Maintenance and operation.** Induction time overcurrent relays are put on all 2300-volt motors and on all feeder or main cable runs. All the motors, being explosion-proof, do not have any overload service factor and are protected at 10 per cent over rated load. Instantaneous trips are set at 10 per cent over the locked rotor current. These are checked once a year by actually passing current through the current transformer primaries, or if no current transformers are used, then directly through the thermal heater strips. Before starting up after a shutdown, the motor, its leads, and starter are megged as a unit. A daily check is made and records kept of ground indicating meters on power and battery lines and pilot light circuits. Once a year, before the rains start, the air passages of the motors are cleaned out and the motor and air passages are painted with a corrosive-resistant paint. This has been found to be very helpful in keeping down corrosion, which is a serious problem in the refinery atmosphere. Oil lubricated motor bearings are checked regularly, but ball bearings are lubricated once a year only, at the time of motor painting, by forcing new grease in, and allowing the old grease to run out while the motor is turning over. They are not disassembled unless there is actual indication of trouble.

The substations and switch houses are unattended but checked regularly on every shift. Maintenance personnel are responsible for checking these substations in their particular units and a complete record is kept of all operation.

The original installation in this refinery was made in 1929. Additional units have been added from time to time. At the present time, the connected load is in excess of 13,000 hp. A decoking plant is now under construction, which when completed this summer, will add another 2000 hp. of connected load.

The adequacy of the steps described herein as a solution to the electrical problems confronted in refinery construction and operation is indicated by the operating record of the refinery. There have been no major refinery shutdowns attributed to the failure of electrical apparatus. The layout of the electrical equipment as described has enabled frequent tests and inspections to be made and thus, possible trouble has been averted. Electrical maintenance and installation around the refinery requires more than the ordinary amount of work to be done on circuits while energized, and the safety record of this refinery is another indication of the soundness of this installation.

In 1929, when this refinery was laid out, the National Electric Code did not require the removal of general purpose electrical equipment from refining areas, and explosion-proof equipment was not available. Today, after 16 years, the principles and methods laid down in the design and layout of the refinery are in line with good engineering practice of the present time. ★★★

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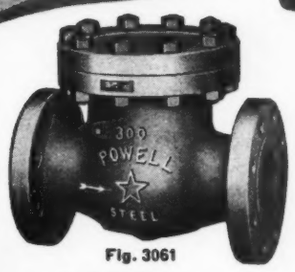

Fig. 3061

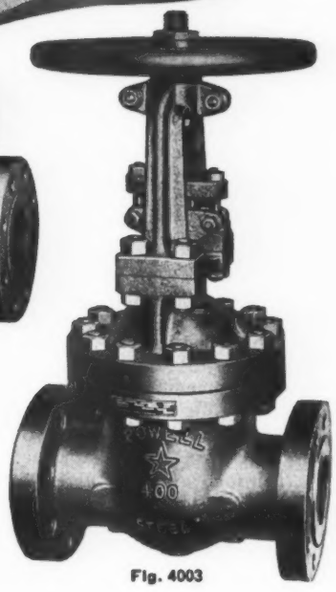

Fig. 4003

Fig. 1460

Fig. 4003—Class 400-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc. Powell Cast Steel Valves are available in pressure classes from 150 to 2500 pounds, inclusive.

Fig. 3061—Class 300-pound Cast Steel Swing Check Valve with flanged ends and bolted cap.

Fig. 1460—Iron Body Bronze Mounted "Master Pilot" Gate Valve. Screwed ends, rising stem, bolted flanged bonnet and taper wedge solid disc. Also available in all iron.

Fig. 1503—Class 150-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc.

Fig. 241—125-pound Iron Body Bronze Mounted Globe Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke, and regrindable, renewable bronze seat and disc. Also available in All Iron.

Fig. 1793—125-pound Iron Body Bronze Mounted Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke, bronze seat rings and taper wedge solid disc. Also available in All Iron.

Fig. 1793

Fig. 241

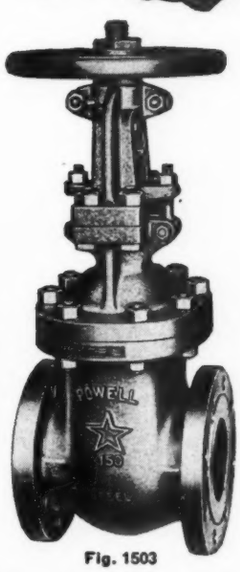

Fig. 1503

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Modern Approach to Pilot Plant Operation

By **W. E. BRADLEY,** Research Department, Union Oil Company of California

RESEARCH, the initial stage in the development of new processes and products, has lately received a large amount of publicity and rightly so as it has contributed immeasurably to our everyday lives. The impression seems to have been created, however, that the chemist or the physicist, or whatever scientist is required, performs a number of simple or complicated experiments in the laboratory and after their successful conclusion, commercial units are immediately constructed and production rolls out according to schedule. Unfortunately, or possibly fortunately, this is not the case. Many of the research projects undertaken, even though successfully completed in the laboratory, are never commercialized and those that are only infrequently go directly from beaker experiments to full scale manufacture in one leap. Between the beaker and the barrel are bucket size or pilot plant operations that carefully sift research findings in order to select the economically feasible projects for further study and the development of necessary engineering data to be used in commercial designs. The pilot plant, therefore, is an extremely important step in the development of new processes and products. It is also highly useful in studying on a small scale contemplated changes in the operation of existing large units.

EXCLUSIVE

Union Oil Company has recognized the importance of pilot plant operations for a long time and in a wartime expansion of research facilities erected a spacious building (Fig. 1) especially designed to centralize units of this type. This building, which measures 47 ft. by 145 ft. with a maximum ceiling height of 55 ft., has a rather unusual internal and external arrangement, and because it has been of interest to many visitors from other companies it will be described in some detail.

The building itself comprises a structural steel frame covered with corrugated transite sheets. A large sliding door is provided at one end as a ready entrance for equipment. The other end of the building has been partitioned off to form rooms on two levels. On the lower level a large room is provided as a general office for foreman and operators. A second room serves as storage space for miscellaneous equipment required in the construction and operation of pilot units and the remaining section is a washroom. On the second floor, two rooms are available as laboratories for the control of operations and the analysis of feed stocks and products (Fig. 3).

W. E. Bradley

The main section of the building, which houses the various pilot units, is divided into four areas with separate drainage systems to facilitate cleaning. Two centrally situated structural steel platforms extending the entire length of the room, one 8 ft. wide at 14-ft. and the other 4 ft. wide at 28-ft. elevations, respectively, are supported by steel columns. Stairways (Fig. 3) provide access to these platforms at one end of the building and escape ladders are installed at the other end. Provisions have also been made for intermediate catwalks where necessary thereby permitting all equipment to be reached easily at any point from the floor to the ceiling.

The pilot units themselves are erected on either side of this central section and, as shown in Fig. 2, all services are carried immediately under the first platform. This arrangement facilitates alterations or repairs to piping, etc., as well as operation of the units.

Along the sides of the building and paralleling the platforms a series of panels have been installed similar in many respects to the operating boards in regular commercial plant control rooms. As will be seen from Fig. 4, all lines from

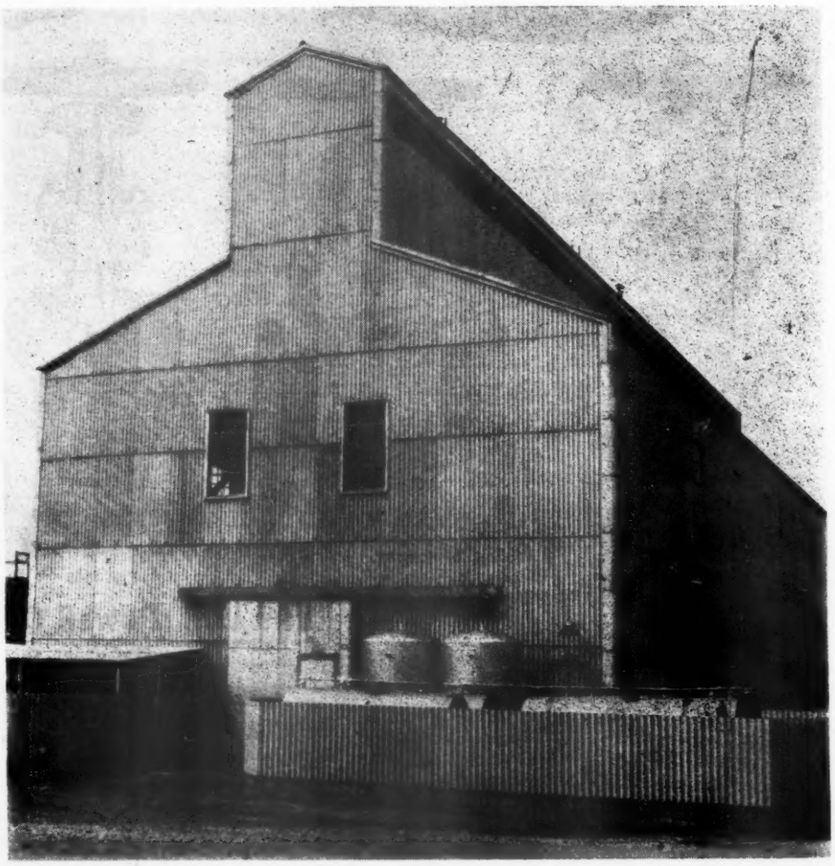
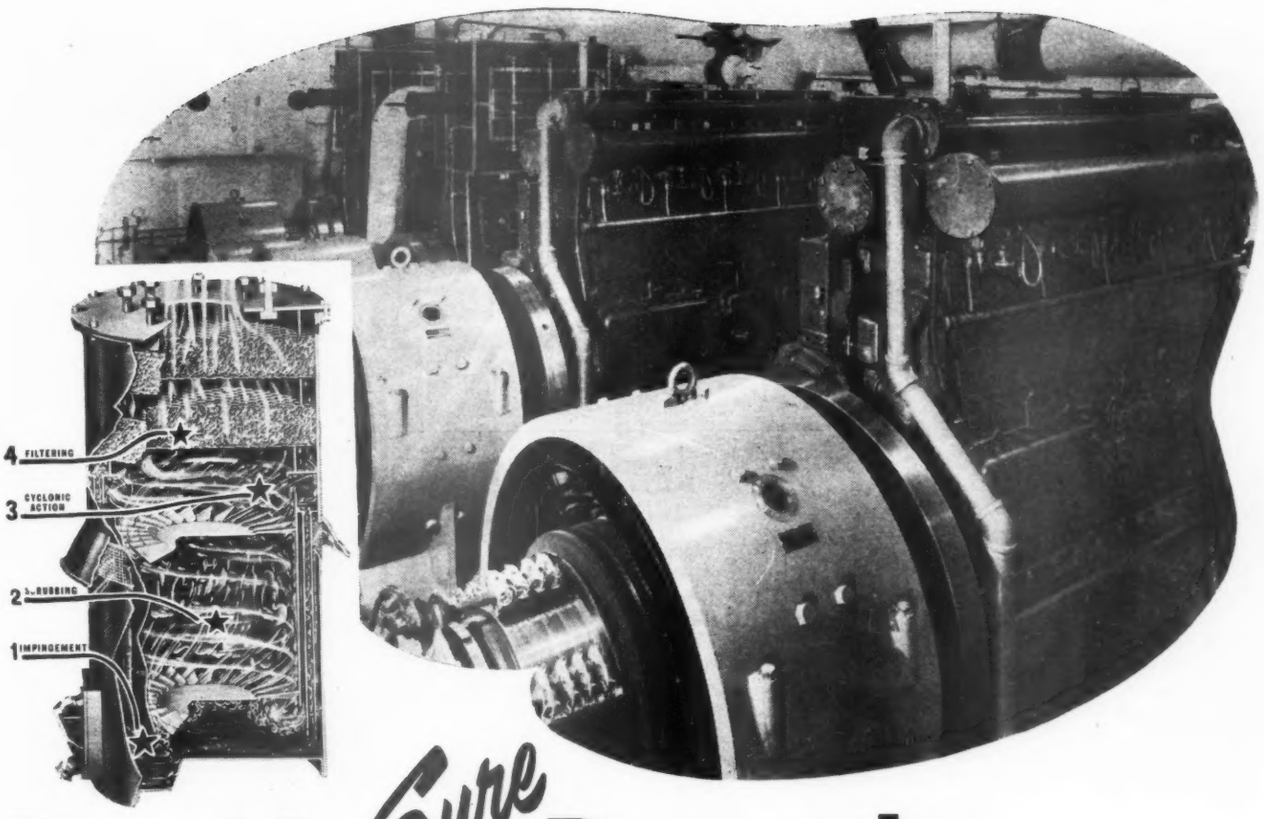


FIG. 1. Union's new building for housing pilot plant facilities. In the immediate foreground is an enclosure containing the feed tanks and product tanks for a catalytic cracking pilot unit inside.



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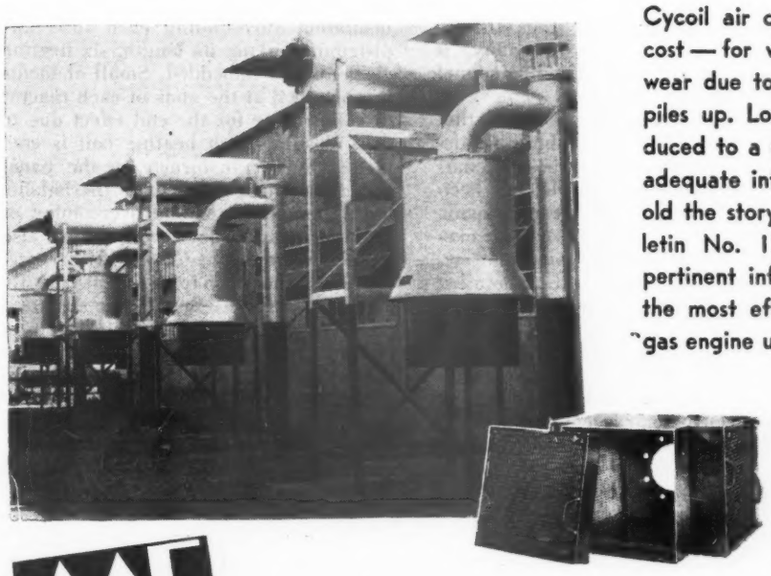

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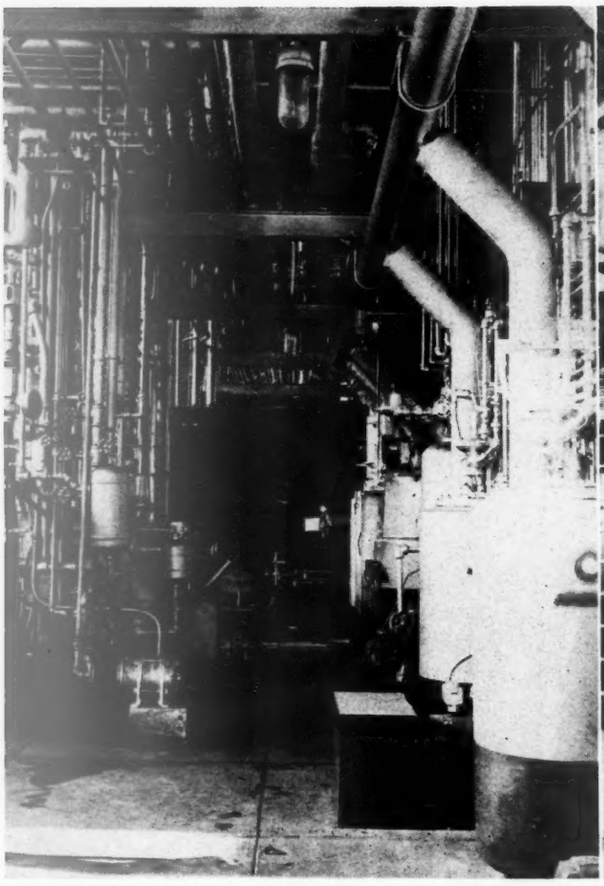

FIG. 2. Miscellaneous services for pilot units are carried underneath the first platform. Portion of a pilot catalytic cracking unit is at right and a hypersorption unit left.

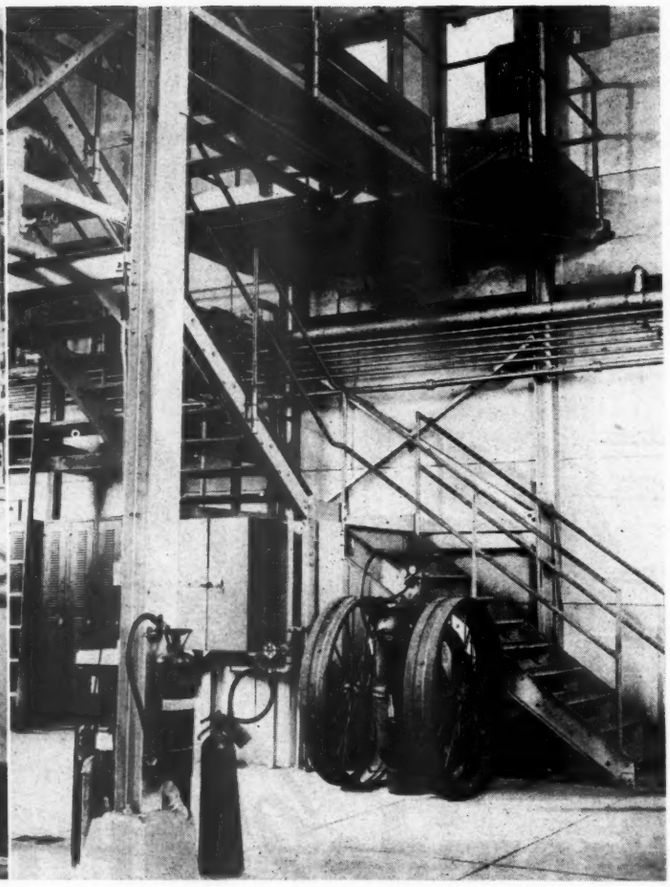

FIG. 3. Stairway leading from the main floor to the first platform along with the entrances to the control laboratories on second floor. Du Gas fire engine in foreground.

a pilot unit to a control board are carried overhead so that they are readily accessible. Except for the extensive use of electricity for heating purposes instead of fuel oil, the control equipment is the same as that found on large scale units.

Although situated in Southern California, adequate provisions have been made for heating by placing forced convection type steam heaters at appropriate points. Several types of fire-fighting equipment have also been installed and these range from small carbon dioxide and Du Gas extinguishers at each unit to 350-lb. Du Gas fire engines at either end of the building (Fig 3). Figure eight fog nozzle type units are also available.

Immediately surrounding the outside of the building are a number of enclosures that serve as storage spaces for feed stocks, electric transformers, etc. For example, as shown in Fig. 5, all high pressure cylinders of nitrogen, hydrogen, oxygen, and carbon dioxide are contained in one enclosure with manifold lines piping these materials to the various units inside. Replacement cylinders are also stored in the same enclosure. Fig. 1 shows an enclosure containing the feed stock tanks and product receptacles forming a part of a pilot catalytic cracking unit. Power requirements for the building are provided from still another enclosure, which, for safety, is locked so that only authorized personnel can gain access.

Insofar as possible the pilot units that have been installed in the building described have been multi-purpose in character. One unit, for example, has been constructed so that studies can be made of any type of catalytic process that may be found in petroleum refining and employing a fixed catalyst bed. A detailed description of this plant should be of interest.

The principal components of the unit are two adiabatic type reactors, each manifolded to permit flow of air, steam, hydrogen, nitrogen, recycle gas, and hydrocarbon feed stocks through the catalyst bed. The valves that control the flow of the above commodities to and from the reactors are situated in a 6-ft. long manifold 5 ft. above the floor in front of and between the two reactors. The valves have all been arranged so that they operate at atmospheric temperature thereby minimizing operating difficulties resulting from packing leaks, which are a problem with valves in high temperature service.

The reactors themselves are constructed of 25-12 chrome nickel alloy tubing of 2¼-in. outside diameter, 1/16-in. wall thickness, and 16 ft. in length. In the insulation surrounding each tube and distributed along its length, six heating elements are imbedded. Small elements are installed at the ends of each reactor to compensate for the end effect due to cold closure. Each heating coil is controlled by a transformer on the panel board. In order to facilitate the balancing of temperatures and overcoming of radiation losses, thermocouples are also imbedded in the insulation with corresponding thermocouples inside the reactor tube. It was found that radiation from the wall of the reactor to the central thermocouples at those points where there was no catalyst bed resulted in appreciable errors in temperature readings. These errors were largely eliminated by the use of radiation shields.

The type of reactor construction described permits the temperature gradient to be established in a minimum period after start-up. It might be mentioned that in previous pilot units, reactors of isothermal characteristics were employed; however, most commercial processes in the petroleum industry are essentially adiabatic in nature and it was found not only impossible to obtain a good correlation with the isothermal pilot unit, but in some instances entirely erroneous predictions were made for the effect of specific modifications in commercial plant operating technique.

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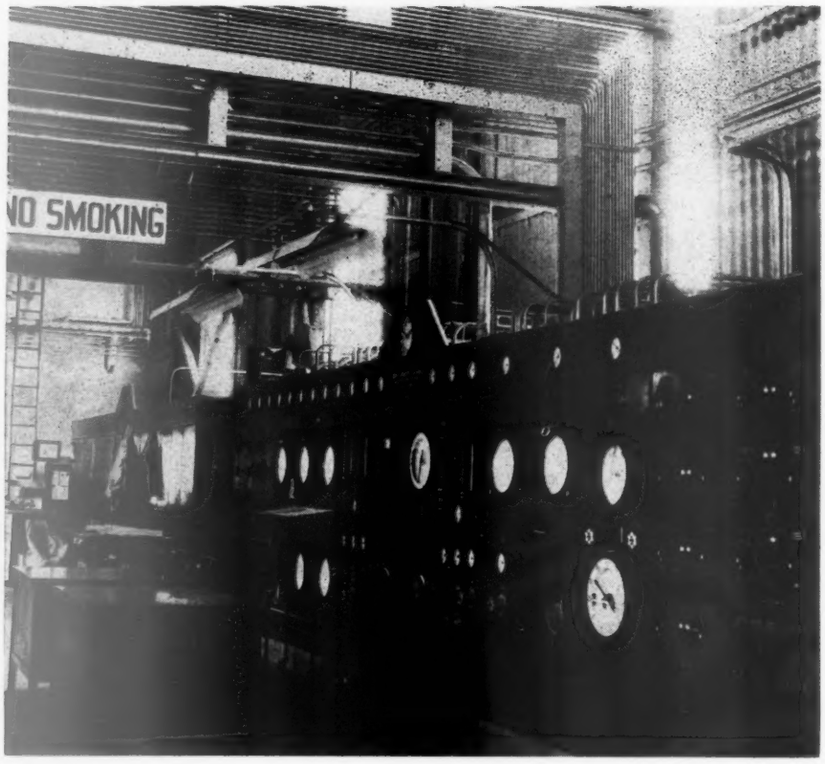
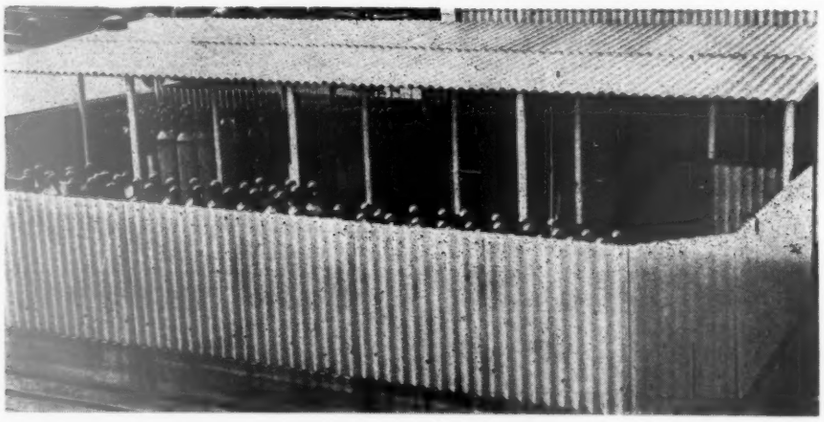


FIG. 4. A typical control board for a pilot unit with the necessary piping being brought overhead.

As nearly all fixed bed catalytic operations comprise a feed stock that is pumped through a preheater, possibly along with an added gas such as hydrogen, and thence through the reactors to fractionating equipment for separating the various components of the product, as well as means for catalyst regeneration, a miscellaneous variety of vessels, heaters, pumps, gas holders, and fractionating towers have been provided in addition to the reactors.

During the war this pilot unit was employed full time as a guide in the operation of an 8000-bbl. per day hydroforming plant concerned with the manufacture from petroleum naphthas of toluene for TNT and xylenes for 100-octane aviation gasoline. The data obtained were extremely valuable in selecting the most appropriate feed stock and establishing optimum reaction conditions. The pilot unit was also used to evaluate new catalyst formulations resulting from extensive laboratory investigations. As a result of this latter work, a catalyst was finally developed that not only gave higher yields of toluene and xylenes but also retained its activity for more than a year where the formerly used material required changing at intervals of only three to four months. It is also of interest to note that in order for data on product yields and quality to be directly comparable to those for the commercial plant, it was necessary to employ an approximately 50 per cent greater space velocity through the pilot catalyst bed.

FIG. 5. Outside enclosure for high pressure cylinders of nitrogen, hydrogen, etc., which are manifolded to lines serving the pilot units.



This has been interpreted as indicating that there is considerable channeling through the commercial catalyst beds and that steps should be taken to improve the distribution of vapors in these reactors.

The foregoing description is illustrative of pilot units for the control and improvement of operations in existing commercial installations. In those cases where the pilot plant represents an intermediate phase in the development of a new process, a maximum degree of flexibility is required in order that major changes can be made in equipment design or arrangement, or both. The unit employed in Union's most recently announced development, "Hypersorption," is a typical example.

Hypersorption is a fractionation process in which the separation of the components of gaseous mixtures is accomplished by means of a moving bed of activated charcoal. The feed gas is countercurrently contacted with the charcoal in an adsorption section in which the temperature and pressure are so regulated that the higher boiling components are selectively adsorbed while the more volatile constituents pass through unaffected and are collected as one of the product streams. The saturated charcoal passes to a stripping section where it is heated and stripped with steam to remove the adsorbed materials and then returned to the adsorption section for reuse. The stripping can be controlled so that the most volatile adsorbed compounds are removed from the charcoal first and collected separately from the heavier constituents.

The initial laboratory work involved extensive studies under varied conditions of the adsorptive properties of charcoal for hydrocarbons and gases such as CO_2, nitrogen, hydrogen, etc. Before proceeding with the design of a unit employing a moving bed to take advantage of the unique properties of activated charcoal, a variety of other aspects were investigated, some on a fairly large scale. For example, one of the first problems that presents itself in any moving bed operation is that of attrition loss. If this factor is high it may render the process impracticable. A unit involving all the movements expected in the final process and especially designed for attrition studies was operated for extended periods of time to determine not only the attrition losses of various types of carbons under such conditions, but also the erosion properties of the carbon particles on the metals of construction. This work demonstrated that certain grades of activated carbon are extremely resistant to powdering and at the same time under some circumstances can erode metal surfaces very rapidly. Recognition of the latter point was extremely helpful in designing the final unit to avoid those types of construction in which erosion would occur.

In another phase of the pre-pilot plant investigations, a fixed activated carbon bed was employed to determine the effect of prolonged usage on the activity of the carbon. It was found, as suspected,

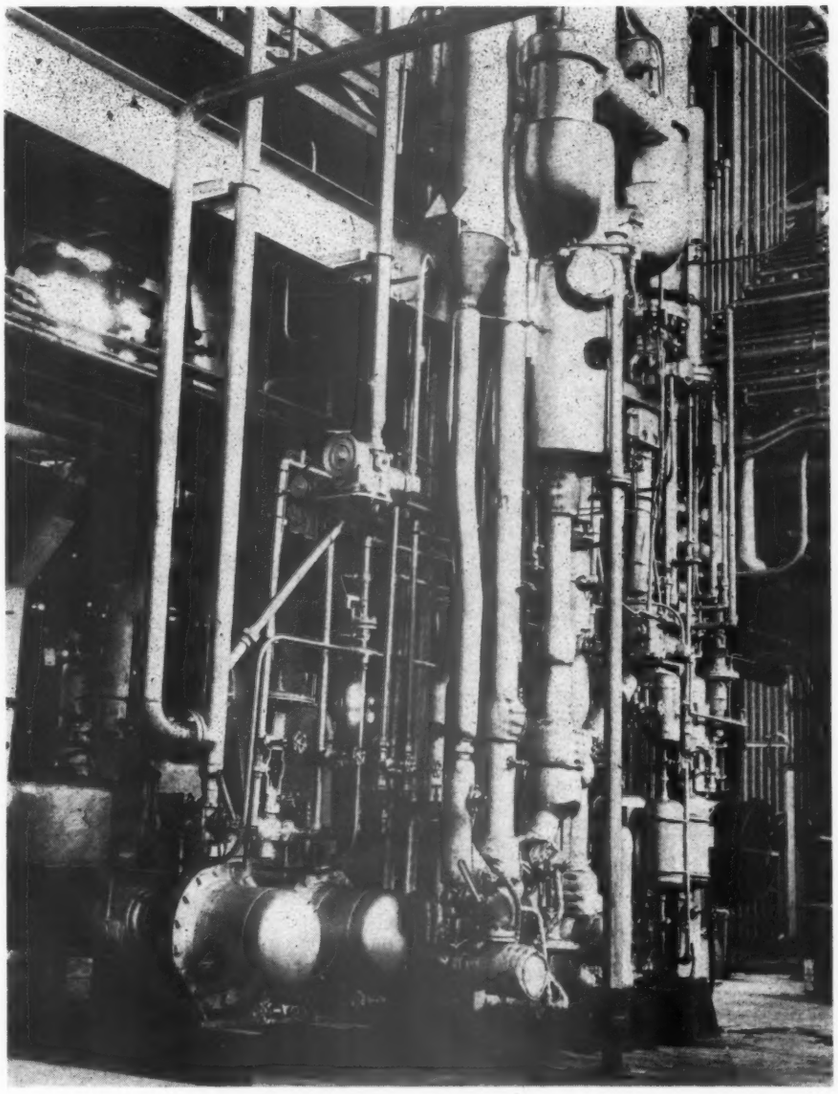


FIG. 6. Lower portion of pilot hypersorption unit shows stripping section and gas-lift line for returning charcoal to top of unit.

that traces of relatively high boiling materials are usually present in commercially available feed gases and after adsorption by the charcoal are not removed in normal stripping operations. Accumulation of these compounds in the charcoal progressively lowered its adsorption capacity and accordingly its efficiency. In order to remove these high boiling constituents and maintain the charcoal at relatively constant activity, a continuous reactivation scheme was developed whereby the charcoal is stripped at high temperatures with superheated steam. Still another phase of the work concerned itself with the flow of solids and these studies were made in glass sections to facilitate observation. On the basis of the information obtained in this work, it was possible to design a mechanism that provided for uniform flow of the charcoal across a large section and at the same time minimized any tendency to disintegrate the carbon into fine particles.

With the background of information from the above miscellaneous studies, a pilot unit (Fig 6) was designed that circulates approximately a half ton per hour of charcoal and processes about 1500 cu. ft. of gas per hr. Despite the preliminary work it was found necessary to make major changes in the arrangement of the equipment, but this was readily accomplished because of the provisions that had been made for interchanging the various sections. At the present time this process is attracting widespread interest as a means of accomplishing gaseous separations not previously considered economically feasible.

The centralization of all pilot units has been found to be very desirable from a number of standpoints. For example, supervision of operating personnel is considerably simplified. Furthermore, under some circumstances fewer operators are required than would be the case with scattered plants. Duplication of services and erection of miscellaneous towers for supporting equipment are eliminated. ★★★

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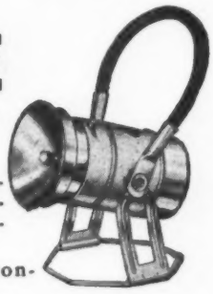

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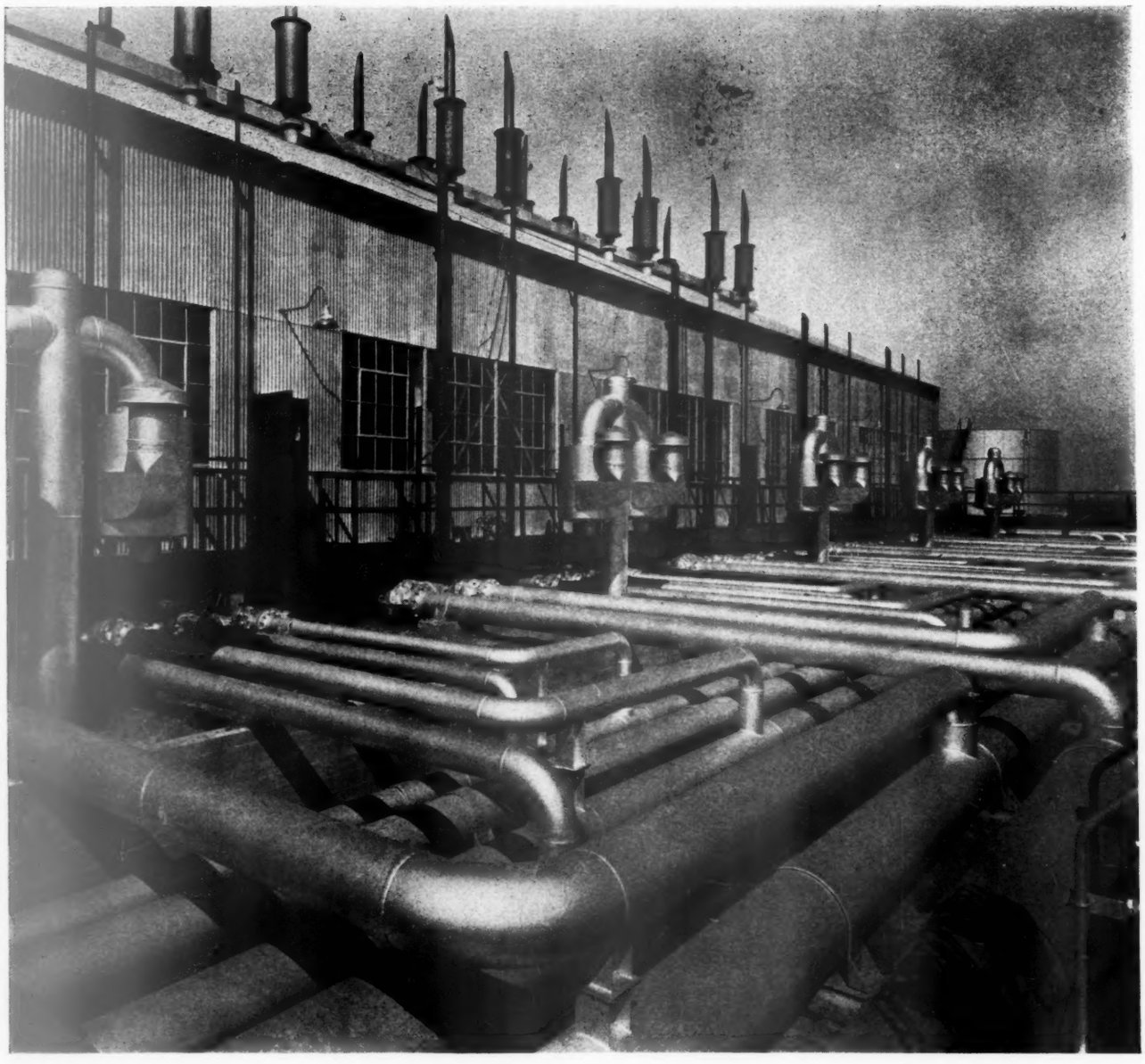

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Absorption Plant Aids Gas Conservation

By **WILLIAM J. DAVIS,** *Associate Field Editor*

EXCLUSIVE

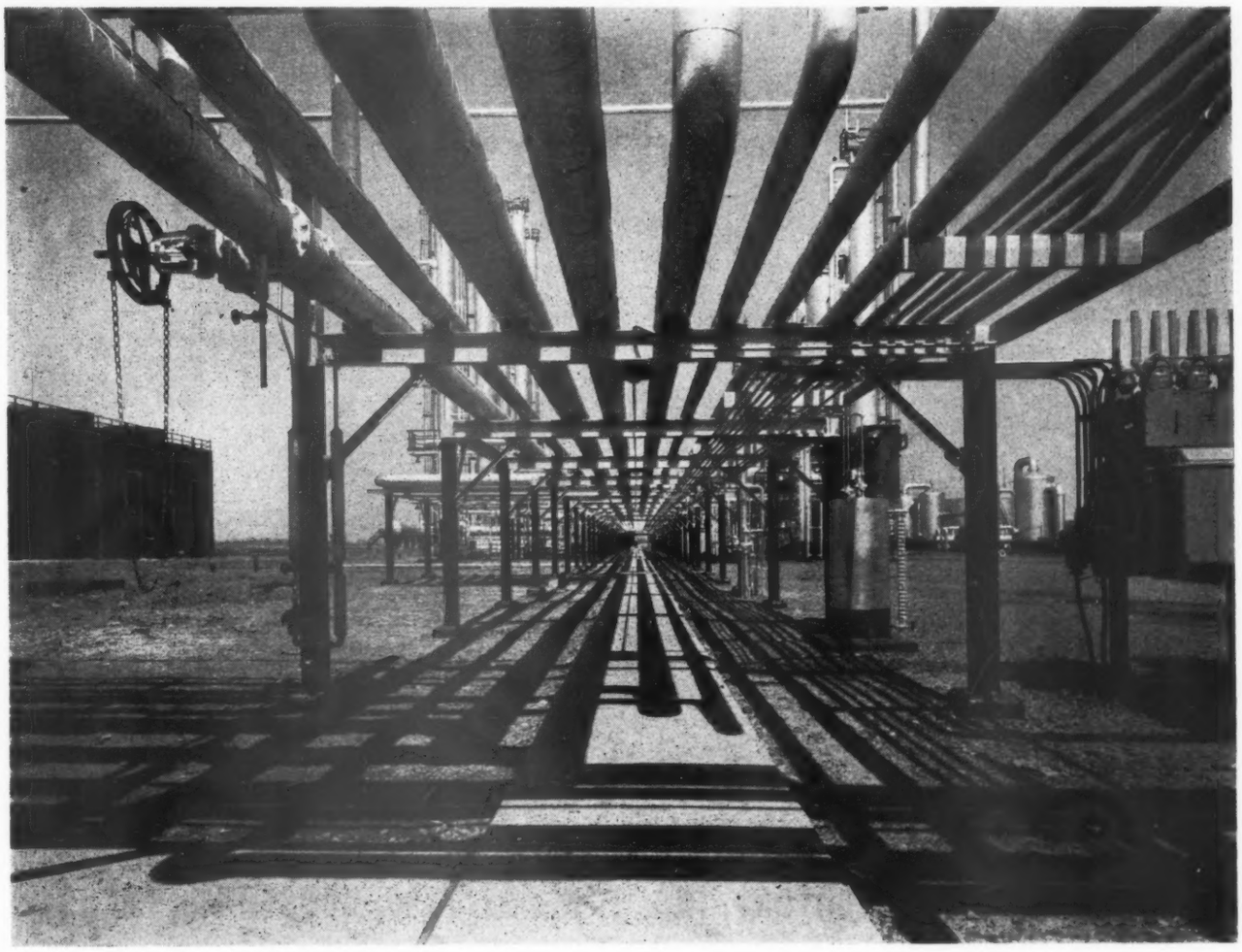
UTILIZING flare gas from the North and South Stowell, Fig Ridge, and Fannett fields, in Chambers and Jefferson counties, Texas, Absorption Plant Incorporated, owned and operated by the Glenn McCarthy interests, is processing approximately 85,000,000 cu. ft. of gas a day for recoverable liquids. The dry gas currently is being sold for domestic and industrial use in the Beaumont, Orange, and Port Arthur, Texas, area.

Situated at Winnie, Texas, 20 miles southwest of Beaumont, the $4,500,000 plant is designed for a capacity of 135,000 gal. daily of propane, normal butane, isobutane, isopentane, natural gasoline, motor fuel, kerosine, and fuel oil and expects ultimately to process 55,000,000 cut. ft. of high pressure gas a day, in addition to the 30,000,000 cu. ft. now processed in the low pressure system, as new industrial consumer plants under construction are completed.

Originally conceived for the production of urgently needed isobutane and isopentane for the 100-octane program, the plant obtained early approval for construction from the War Production Board in October, 1944. Construction was begun in January, 1945, and the compressors were put into service in October of the same year. Meanwhile, the cessation of hostilities brought about unusual fluctuations in the demand for liquefied petroleum products, which necessitated some minor changes in design to increase the flexibility of the plant for varying load conditions. By January, 1946, however, all units of the plant were in successful operation.

Because of the faulted nature of some of these fields, as well as the multiplicity of producing zones and interspersion of oil and condensate producing formations, no uniform gas and gas-condensate field exists at present in that area that would make cycling of the dry gas feasible. With no market outlet available, the individual wells were venting to the

Piping arrangement connecting boiler and heater section of plant to distillation and fractionation section.



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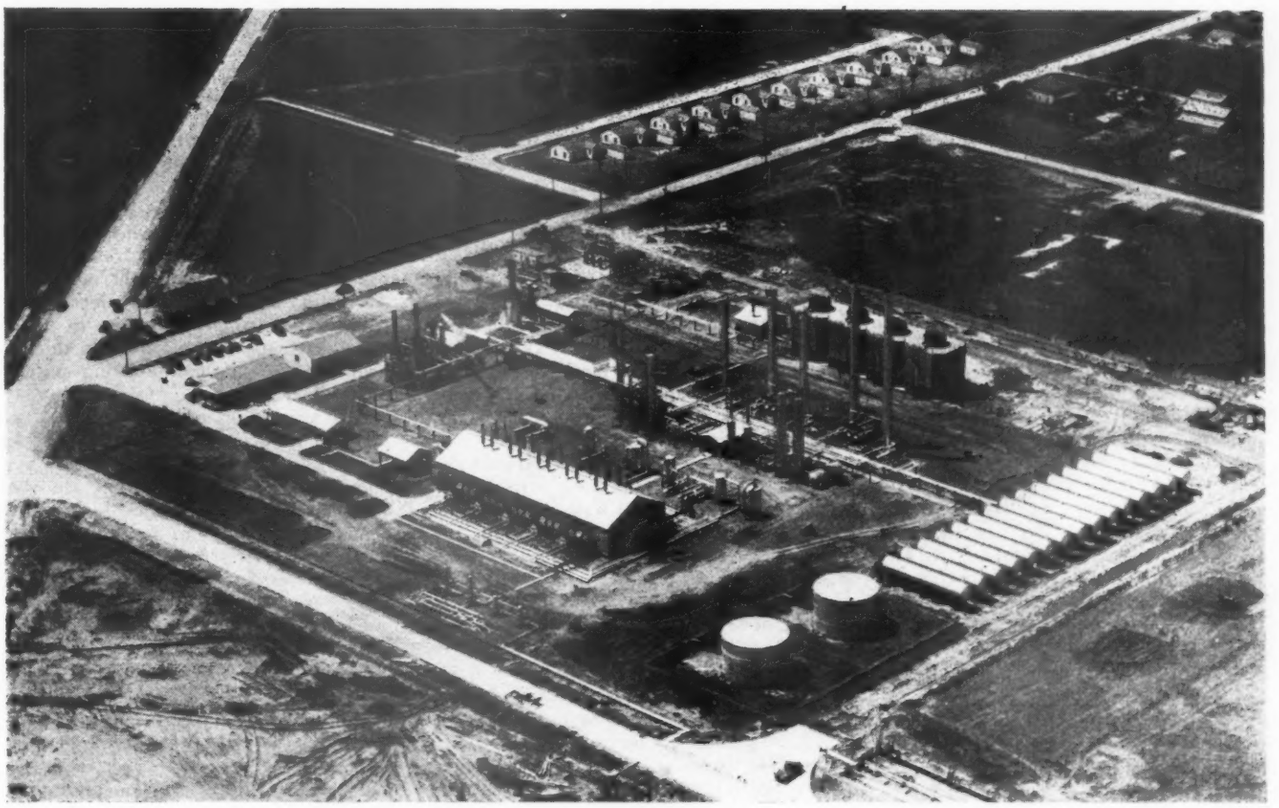
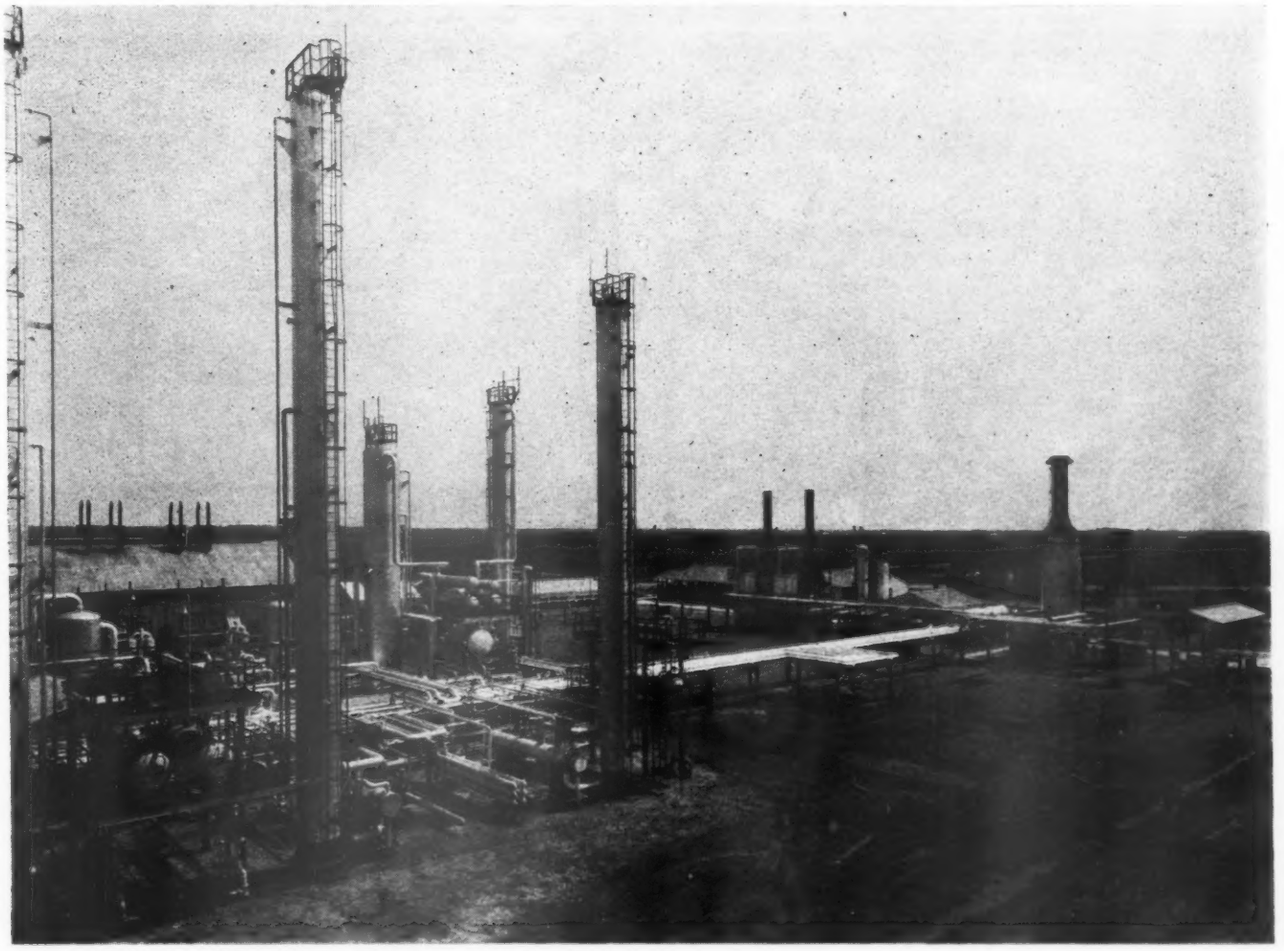


Aerial view of Absorption Plant, Inc., with camp in background.
Refinery section of plant with boilers and oil heaters in background.



air a total of 30,000,000 cu. ft. per day of low pressure gas before the Winnie plant went into operation.

The gathering system is divided into a low pressure system and a high pressure system.

A low pressure gathering system consisting of 60 miles of pipe varying from 2 in. to 30 in. delivers low pressure gas to the plant for processing. There is also a 15-mile high pressure system taking gas from eight condensate wells at present and delivering it to the plant at a pressure of 825 lb. per sq. in. ga. In both systems all liquids are separated from the gas at the wellhead.

In the high pressure gathering system, the condensate separated out at the wellhead is metered by means of a recording dial rotary type meter and then recombined with the gas at a point downstream from the gas meter, after which both liquid and gas flow in the same line to the plant for processing. A backpressure valve on the downstream side of the gas meter run holds approximately 20 to 40 lb. per sq. in. pressure differential, which allows the liquid from the separator dump valve outlet to enter the gas line without difficulty.

At the plant the gas and condensate are again separated by plant separators with the liquid going to processing tanks while the gas is routed through the absorption system for final drying before entering the 10-in. gas transmission line for market. No pressuring is necessary.

The low pressure gas enters the plant under slight vacuum in the 30-in. line and is scrubbed before being introduced in the compressors. Compressor suction is usually set at 6 in. vacuum.

Ten 8-cylinder, 800-hp. angle compressors, each having four compression cylinders, take suction from the incoming gas scrubbers at approximately 12.2 lb. per sq. in. ga. and compress to 450 lb. per sq. in. ga. in three stages. On each engine two cylinders handle low pressure gas with the third as intermediate and the fourth as high pressure. The gas is water-cooled and the condensed liquid removed after each stage of compression.

The compressors are installed back-to-back for efficient operating supervision. A pressure controlled butterfly valve on the suction manifold of each bank of engines assures constant suction pressure, and a central speed control varies the speed of the engines as the load or demand for gas changes. Individual suction and discharge lines to the compressors are laid horizontally and have right angle expansion bends. Compared with high pressure cycling installations, these lines are relatively large in diameter and vertical expansion loops would have been unwieldy.

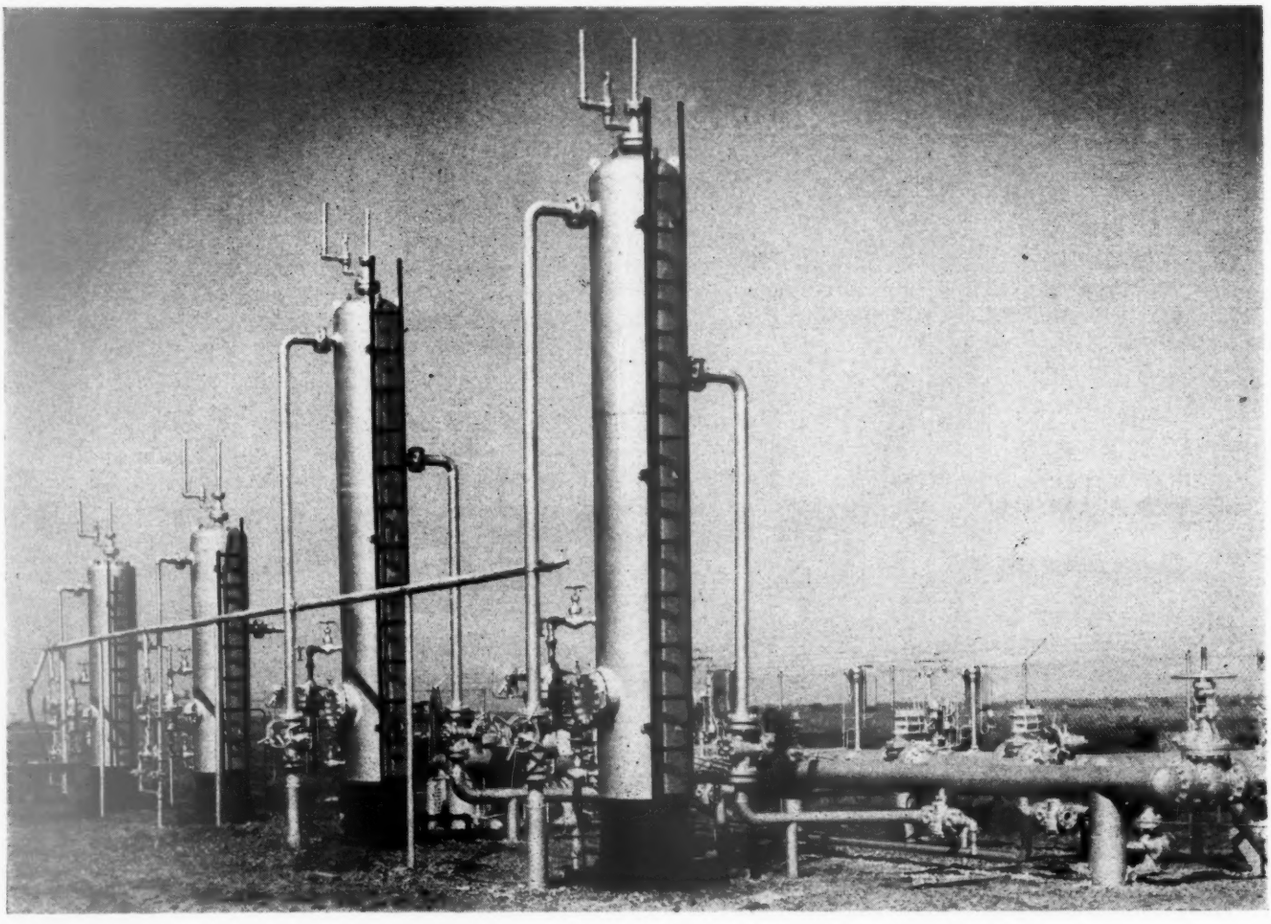
Jacket cooling water lines to the compressors are in covered floor trenches and return lines pass overhead to reduce air and vapor lock. Water to the compressors is supplied by three 3700 gal. per minute centrifugal pumps operating at 39 lb. per sq. in. pressure differential, two of which are driven by 100-hp. 2300-volt electric motors, and the third by a steam turbine. All jacket makeup water is supplied from clean steam condensate, which reduces the concentration of deposit-forming minerals in the jackets.

Starting and instrument air is provided by three compressors, two of which are electrically driven, and the third is connected to an engine using natural gas as fuel.

Gas absorption is carried out in two 22-plate absorbers. Gas at 825 lb. per sq. in. ga. from the plant separator system is charged directly to one absorber and then flows to one of the 10-in. natural gas transmission lines for market. Gas from the compressors at 450 lb. per sq. in. ga. is charged to the alternate absorber, after which it is piped to a second 10-in. natural gas line for marketing purposes.

An interesting feature of the absorption oil system is the economy of oil circulation effected by the use of high pressure absorption oil from the high pressure absorber in the lower section of the low pressure absorber. The high pressure rich oil flashes as it enters the mid-

Battery of separators used to separate high pressure gas from condensate at the plant.



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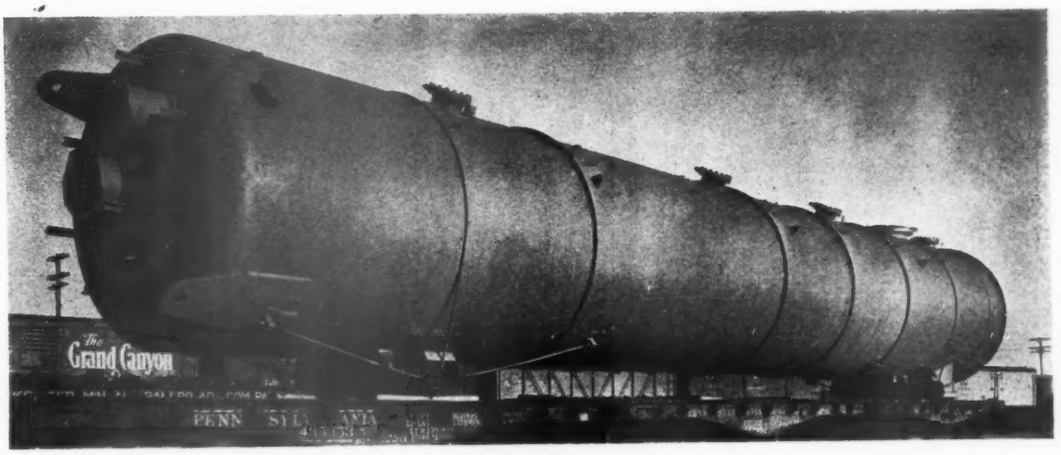

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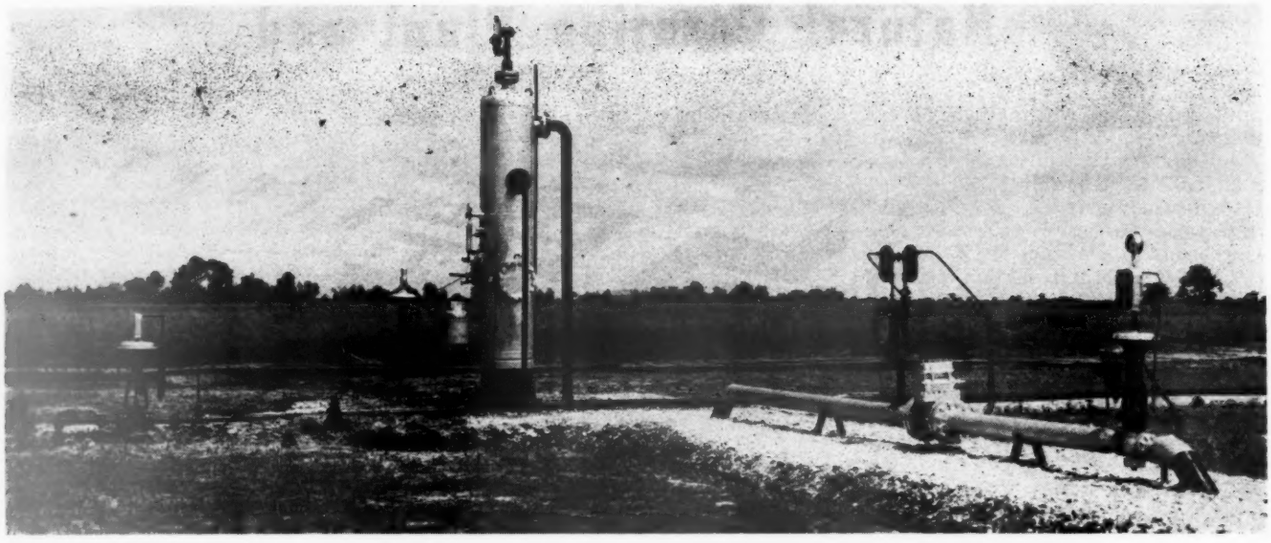


One of eight condensate well separator arrangements whereby condensate is separated from well gas, metered for payment, and then piped back into the 6-in. gas flow line at a point downstream from regulator shown at extreme right.

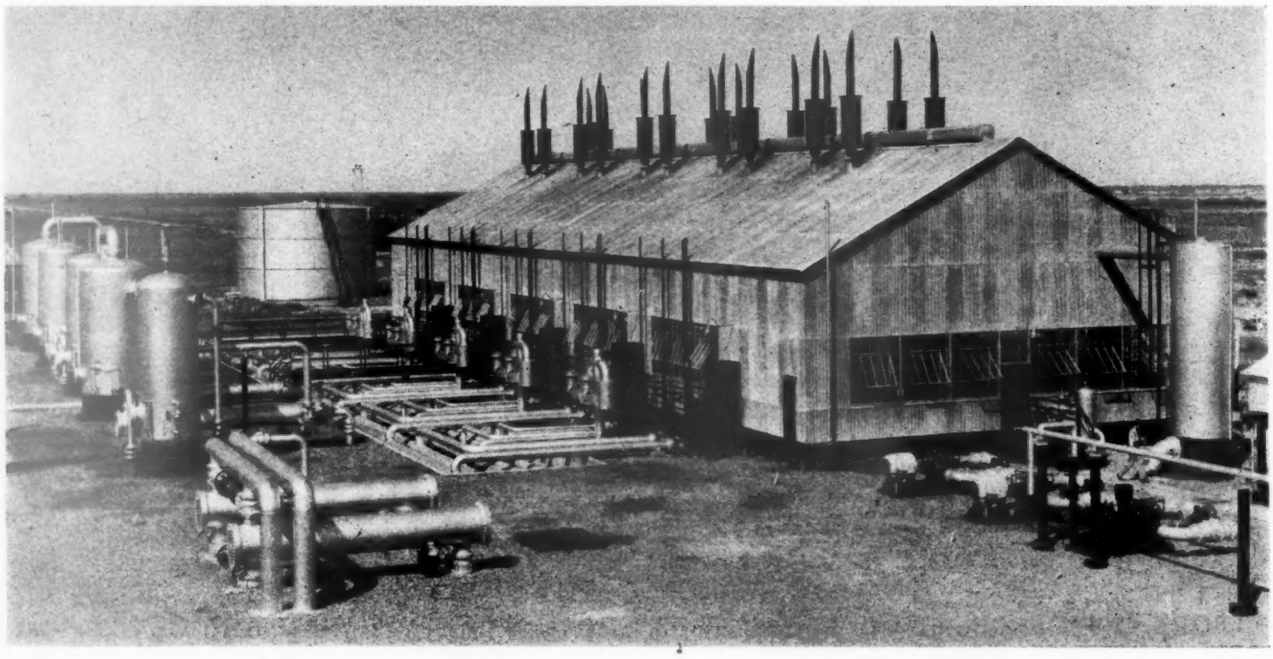
section of the low pressure absorber, losing considerable methane and undesirable constituents. It is further demethanized in the lower section by contact with the rich low pressure gas. At the same time its propane and butane content are increased. Final stripping of the low pressure gas and vent gas is accomplished in the upper section of the low pressure absorber with a stream of lean oil. The total lean oil requirements are reduced approximately 40 per cent by this piping arrangement, as compared with separate handling of the high pressure and low pressure rich oil streams.

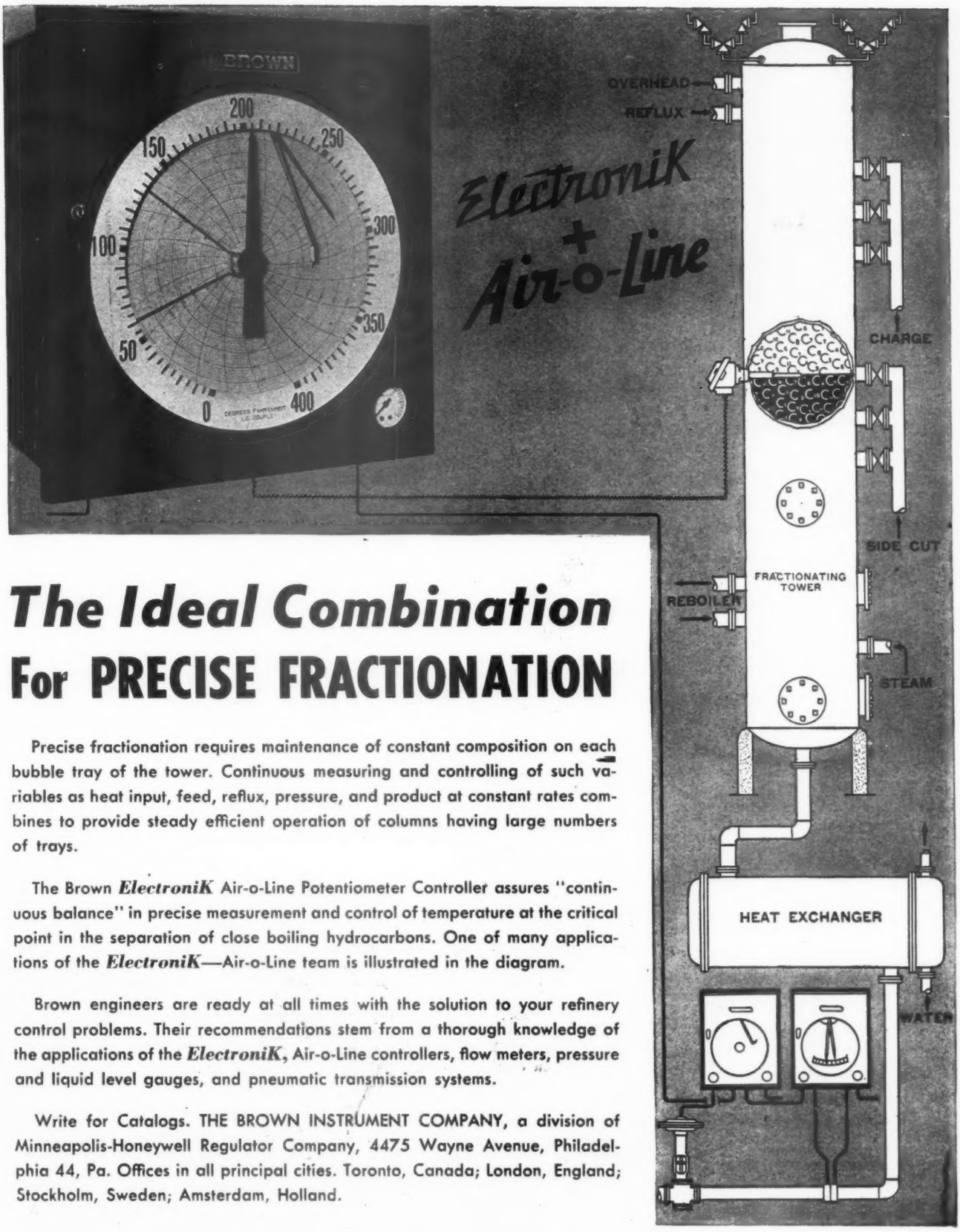
The low pressure vent consists of a large diameter lower section and a small diameter upper section containing 14 trays. The rich oil from the intermediate pressure vent is introduced at the top of the lower section of the low pressure vent. A flash takes place at the entrance to the vent and the rich oil absorbs vent ethane and propane from the rich low pressure vent gas, which is introduced at the bottom of the lower section. The flashed gas is stripped of butane and propane by a lean oil stream introduced at the top of the upper section. Due to the arrangement of the oil and gas flow in the low pressure absorber and the low pressure vent, a high recovery of propane is obtained with an economical oil circulation.

Absorption oil at 42-deg. gravity for both absorbers is pumped from a surge tank by three electrically driven centrifugal pumps, and oil for the absorber operating at 825 lb. per sq. in. ga. is further increased in pressure by two booster pumps in series with the primary lean oil pumps.

Rich oil from the last vent tower is charged through a heat exchange system against hot oil and then to a vertical gas fired furnace developing 19,700,000 B.t.u. per hr. where the rich oil is heated to 450°F. Raw gasoline is stripped from the hot rich oil in a 20-tray still, after which the hot lean oil is cooled and flows to the surge tank. The use of a direct-fired heater allows the use of a high oil temperature. The still operates at high pressure because of the large

A view of the compressor house with engine jacket water coolers in the left foreground, inter-stage scrubbers to the rear, and the compressor manifold pit containing right-angle expansion bends of all suction and discharge lines.





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Ten 800-hp. compressors arranged back-to-back compress dry gas to 450 lb. per sq. in. ga. for domestic and industrial consumption.

quantity of propane and butane recovered.

Raw gasoline is charged to an ethane tower through two 14-stage vertical centrifugal pumps, operating at 550 lb. per sq. in. ga. discharge pressure.

The deethanized product enters a propane tower, and commercial propane is produced as an overhead liquid product. Stabilized natural gasoline or motor fuel can be produced as bottom product from the butane tower. Overhead butanes can be split further in an isobutane tower. As an alternate operation, bottoms from the butane tower can be charged to an isopentane column for production of an overhead isopentane cut and a stabilized motor fuel bottoms product suitable for leading.

The condensate from the high pressure wells after stage flashing is charged to a low pressure fractionating tower operated in accordance with refinery practice. A gasoline stream is produced as an overhead product and naphtha and kerosine streams can be produced as sidestream products using strippers on each sidestream.

All fractionating towers and related equipment were laid out back-to-back in order to provide one central operating aisle. Condensers and accumulators were grouped for each pair of towers to economize on structural steel for supporting overhead equipment. All processing equipment is grouped in an area less than ten acres in extent, yet ample space has been provided between compressor house, fractionating and storage areas in accordance with usual gasoline plant practice.

Plant storage facilities consist of fifteen 35,000-gal. 60-ft. by 10-ft. diam. horizontal steel pressure tanks for liquid products, two 5000-bbl. bolted tanks for distillate storage, and one 25-ft. by 10-ft. diam. underground storage drum for lubricating oil storage.

Liquid products can be loaded either at a double track railroad rack with 16 jacks or at two truck loading racks. Vapor return lines are provided at both locations.

Plans are now under way to add an Ethyl blending plant and three 5000-bbl. welded steel circulating and motor fuel storage tanks to the present operations.

Electrical power is supplied to the plant by an overhead 33,000-volt feeder from an utilities line. This is stepped down to 2300 and 440 volts at the plant limits. All 2300-volt motors are fed through an underground cable system. Lines operating at 440 volts are run in conduit overhead. A 115-volt lighting circuit is obtained where needed by stepping down the 440-volt line. All spare electric-driven equipment is supplied with current through independent circuits. An underground grid is provided for grounding the electrical system.

Steam at 175 lb. per sq. in. is supplied from two gas-fired bent tube boilers, each capable of supplying total requirements of 30,000 lb. of steam an hr. Induced-draft fans are driven by steam turbines. Boilers are supplied by two steam-driven reciprocating pumps and all boiler feed water is treated by a hot lime process.

All steam condensate of good quality is returned to the boilers. Steam condensate from the rich oil still is separated and returned in an individual line to a horizontal oil skimming tank before being combined with trap condensate. Steam condensate is deaerated and heated by contact with exhaust steam together with boiler feed make-up in a strip tower.

The cooling tower is of induced-draft design with four cells. No atmospheric cooling coils have been used in the cooling tower, as all water-cooled units are of shell-and-tube construction. This has simplified piping layouts and cooling tower construction. Cooling water is treated by chlorination to minimize the formation of algae, and chemical treatment of make-up water for pH control and scale prevention is also included.

Circulation of cooling water for all coolers and condensers is supplied by two 7000 gal. per minute centrifugal pumps each driven by a 370-hp. 8-cylinder V-type engine using natural gas as fuel.

The fuel system is designed to utilize 1,900,000 cu. ft. a day of low pressure vent gas with about 1,800,000 cu. ft. daily make-up from the high pressure system. The compressor house, boilers, furnaces, and gas-engine-driven water pumps are provided with individual pressure regulators.

Water is supplied to the plant by two off-site wells drilled to an average depth of 220 ft. Each well can supply normal plant requirements and they are pumped by 550-gal.-per-min. turbine pumps driven by 50-hp. gasoline-natural gas engines.

Foam systems are provided for fire protection to each of the 5,000-bbl. distillate tanks. Besides portable foam generators strategically situated in the plant, a 6-in. underground water line supplies water to 18 fire hose stations equipped with fog nozzles.

The office building for supervisory personnel also contains the laboratory for routine and analytical testing and is of

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Distillation and fractionation towers of absorption plant.

wood frame construction covered with asbestos siding and asphalt roof shingles. The warehouse is of similar construction. The compressor house, the combined locker room, repair and meter shop, the control house, and the water treating building are of steel frame construction covered with galvanized iron sheeting.

A camp for ten houses is provided for key personnel with all utilities being provided from the camp. Each house is wood frame construction with asbestos siding, hardwood floors, and composition roofing. There are two 6-room houses and eight 5-room houses, all provided with garages.

Approximately 50 men are employed at Absorption Plant Incorporated under the direction of J. M. Sappington, superintendent, Leon Dorsey, process engineer, H. G. Holmes, chief repairman, W. E. Vaughn, chief clerk, Earl Scott, field foreman in charge of high pressure gathering system and high pressure wells, T. S. Gordon, field foreman in charge of low pressure gas gathering system, and J. L. Boyd, chief chemist.

The plant was designed and constructed by Stone and Webster Engineering Corporation. The gathering system was laid by J. R. Horrigan Construction Company under the supervision of engineers from Glenn H. McCarthy and Stone and Webster Engineering Corporation. The housing project was designed and erected under supervision of Glenn H. McCarthy engineers. ★★★

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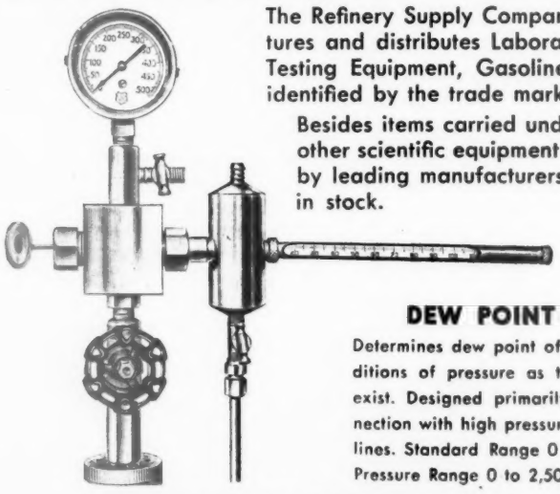

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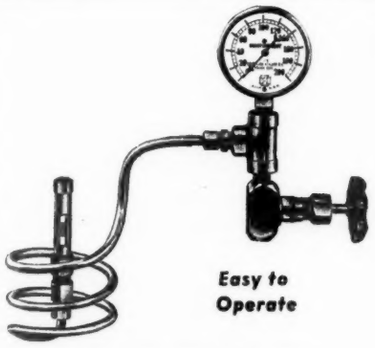

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HYDROCARBON THERMODYNAMICS*

By **WAYNE C. EDMISTER,** Foster Wheeler Corporation

PART 3—Conclusion

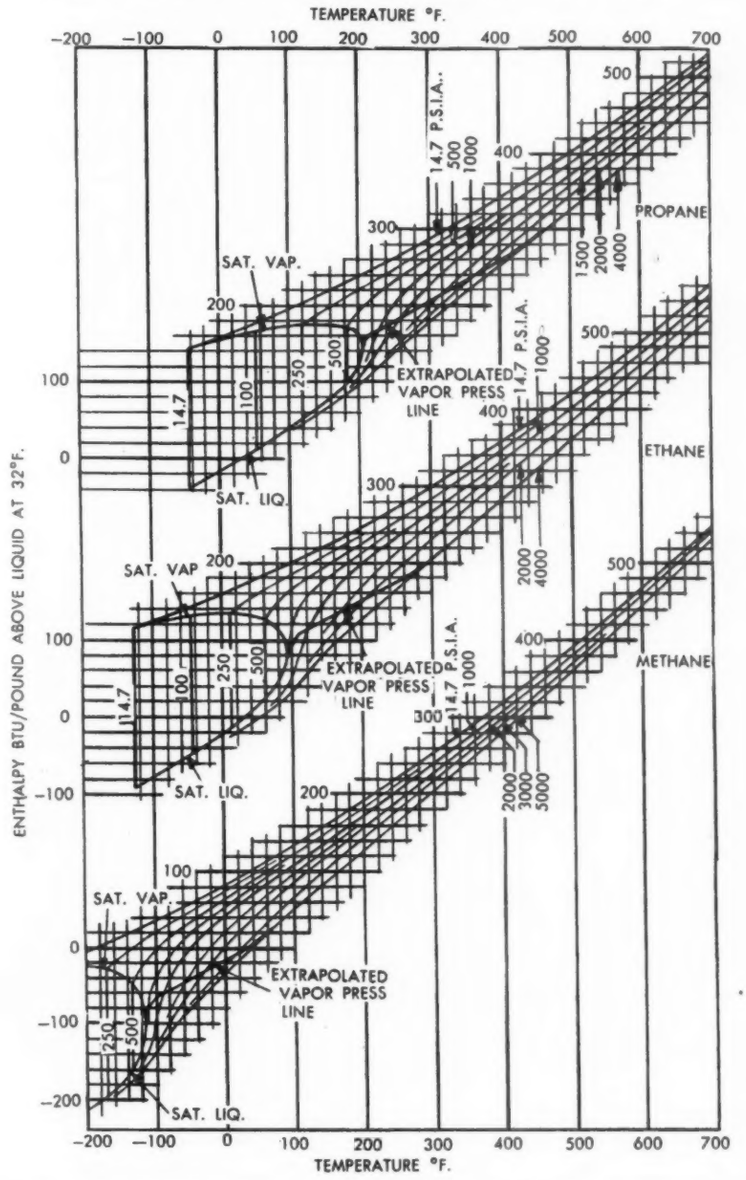
● **Enthalpy — entropy charts.** It is necessary to know differences in the enthalpy (heat content) in making heat balance calculations for hydrocarbon operations, which may take place at constant pressure, temperature, or entropy. In the latter case the quantitative value of the entropy is not required, it being sufficient to know that the entropy remained constant. Differences in entropy are rarely required. Enthalpies and entropies may be tabulated as in the steam tables or presented graphically in the form of Mollier diagrams. There are two types of Mollier diagrams in use, the most well known probably being the type using entropy and enthalpy as the coordinates with lines of constant temperature and pressure in the vapor region, and the other being the type using enthalpy and pressure (the latter on logarithm scale) as the coordinates with lines of constant temperature and entropy in the vapor region. Diagrams of this type may be prepared for pure components and for mixtures as well. The preparation and application of such diagrams for hydrocarbon systems will be discussed, with a few sample charts as illustrations.

The Mollier diagrams for steam and ammonia have long been a very useful tool of the engineer. Many years of work have gone into the development of these diagrams. Hydrocarbon systems are much more complex because of the large number of components and the unlimited number of mixture compositions. By the methods described below, enthalpy-entropy diagrams may be prepared for single or multi-component hydrocarbon systems.

Entropies and enthalpies are computed for pure hydrocarbons by applying the equations given in Table 3 and the correlations given in Figs. 1, 7, 8, 10, and 11. Entropy vs. temperature and enthalpy vs. temperature plots are constructed from the results of these calculations. This is done by selecting a datum point, which may be liquid at any desired temperature or it may be vapor at specified temperature and pressure conditions, and then building the chart up from this point with latent heats, effects of pressure and temperature being involved in the construction. Enthalpy plots for three light paraffin hydrocarbons (methane, ethane, and propane) are shown in Fig. 17. These plots are for reference only. Similar plots can be made for the entropy in like manner. The entropy and enthalpy plots can then be combined to form a Mollier diagram. Such diagrams are shown on Figs. 18 and 19 for propane and butane. The datum or reference state for the enthalpy diagrams in Fig. 17 is liquid at 32°F., whereas the datum for the Mollier diagrams in Figs. 18 and 19 is liquid at minus 200°F. These datum points are arbitrary, 32°F. being selected for the enthalpy plots to make them consistent with other charts and minus 200°F. being selected for the Mollier diagrams in order to avoid having any negative values of enthalpy when applying the charts to refrigeration calculations.

It will be noted that "extrapolated"

FIG. 17. Hydrocarbon Enthalpy Plots (References 6, 20, 22)



*Presented before California Natural Gasoline Association, Los Angeles, November, 1945.

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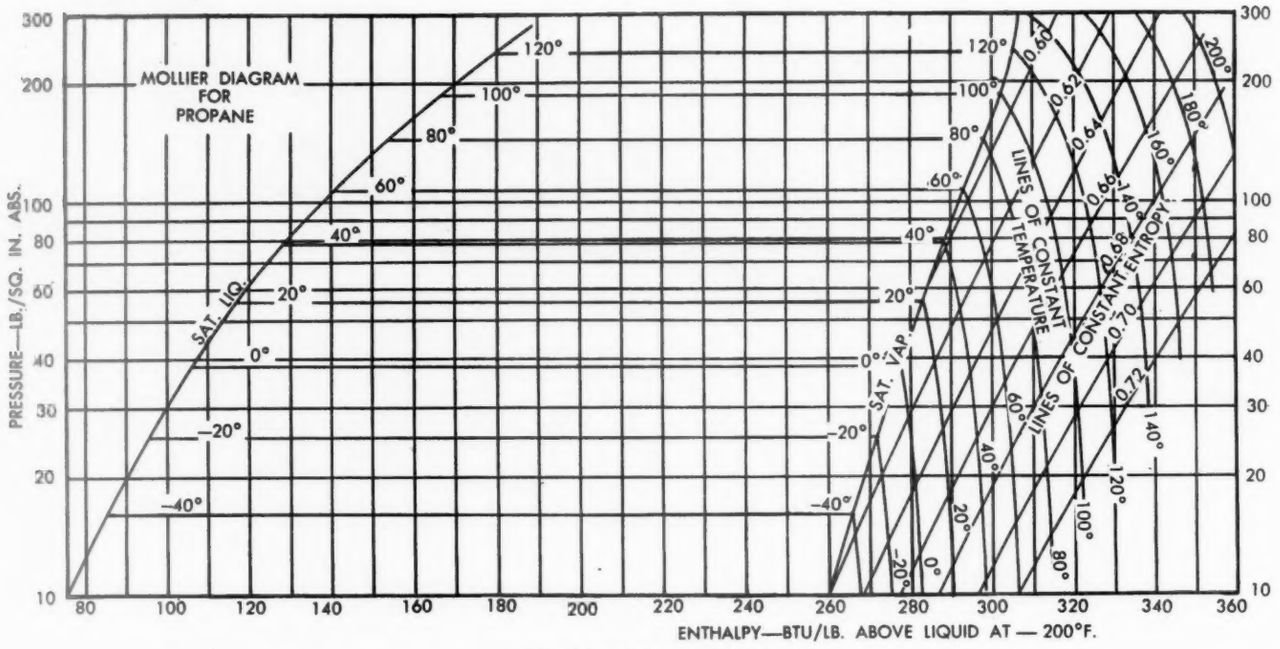

FIG. 18 (Reference 20)

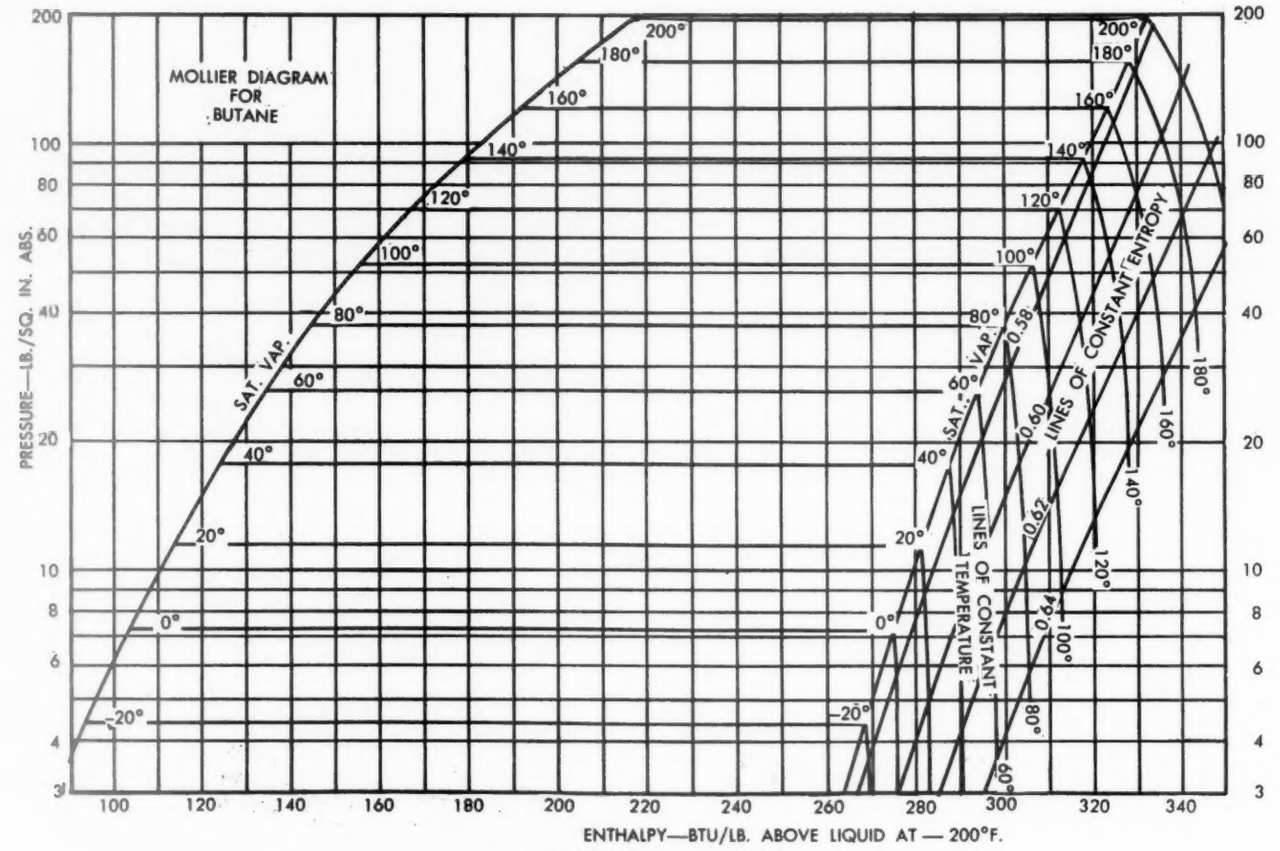

FIG. 19 (Reference 20)

vapor pressure lines are drawn on the enthalpy diagrams in Fig. 17. These lines give the enthalpies for hypothetical liquid conditions that exist when the component in question is a lighter component of a liquid hydrocarbon mixture. These extrapolated vapor pressure curves are obtained from a Cox type vapor pressure plot by extrapolating above the critical point. Enthalpy plots like those in Fig. 17 may be applied to hydrocarbon mixtures by the procedure outlined below.

The temperature, pressure, and phase conditions encountered in most heat balances involving light hydrocarbons are such that either one or both of the following phenomena exists: (a) A liquid hydrocarbon mixture at a temperature higher than the critical temperature of some of the lighter components therein, and (b) a vapor hydrocarbon mixture under a pressure higher than the vapor pressure of some of the heavier components therein. The conditions at which the enthalpies for the components of hydrocarbon mixtures should be read

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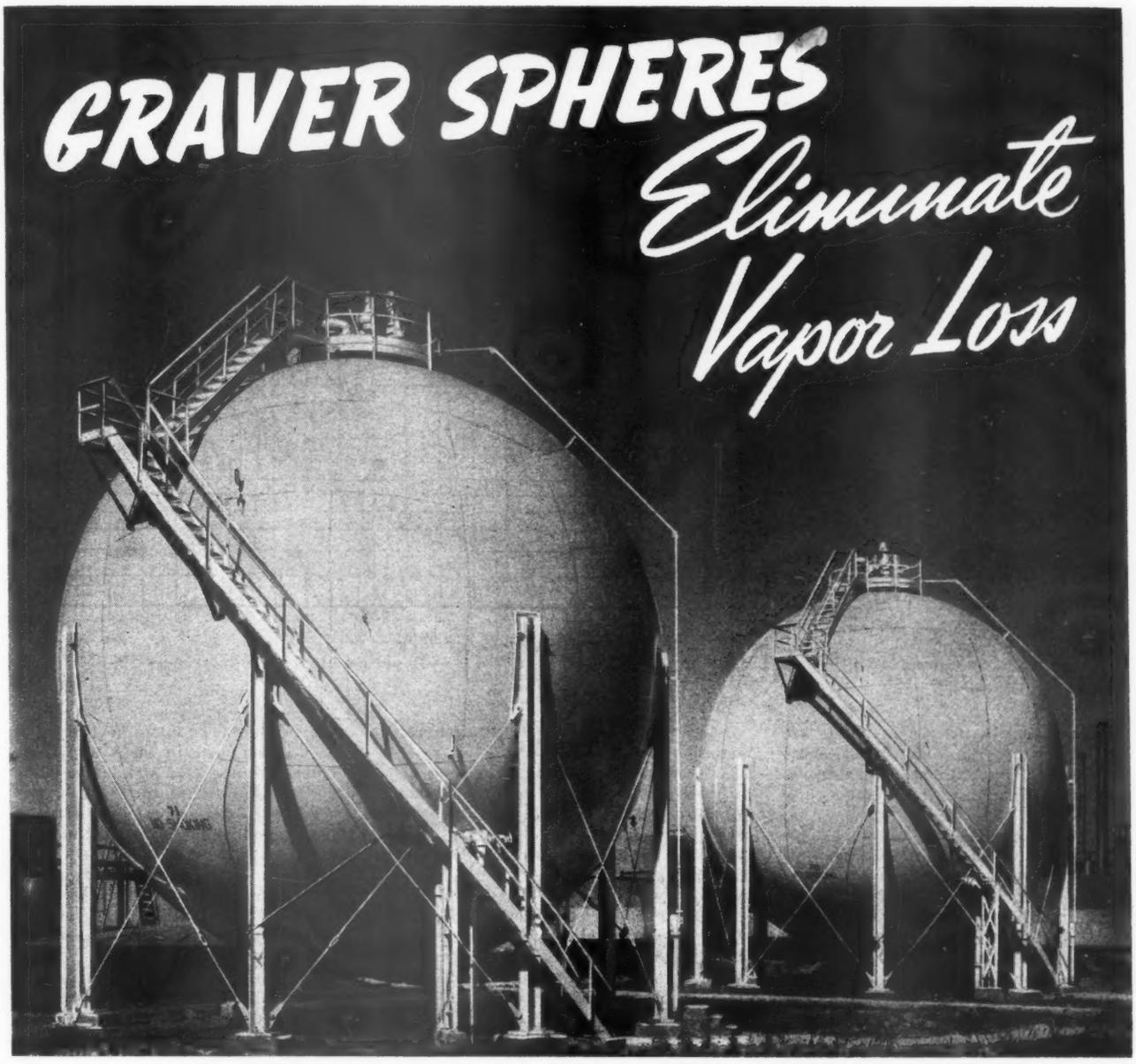

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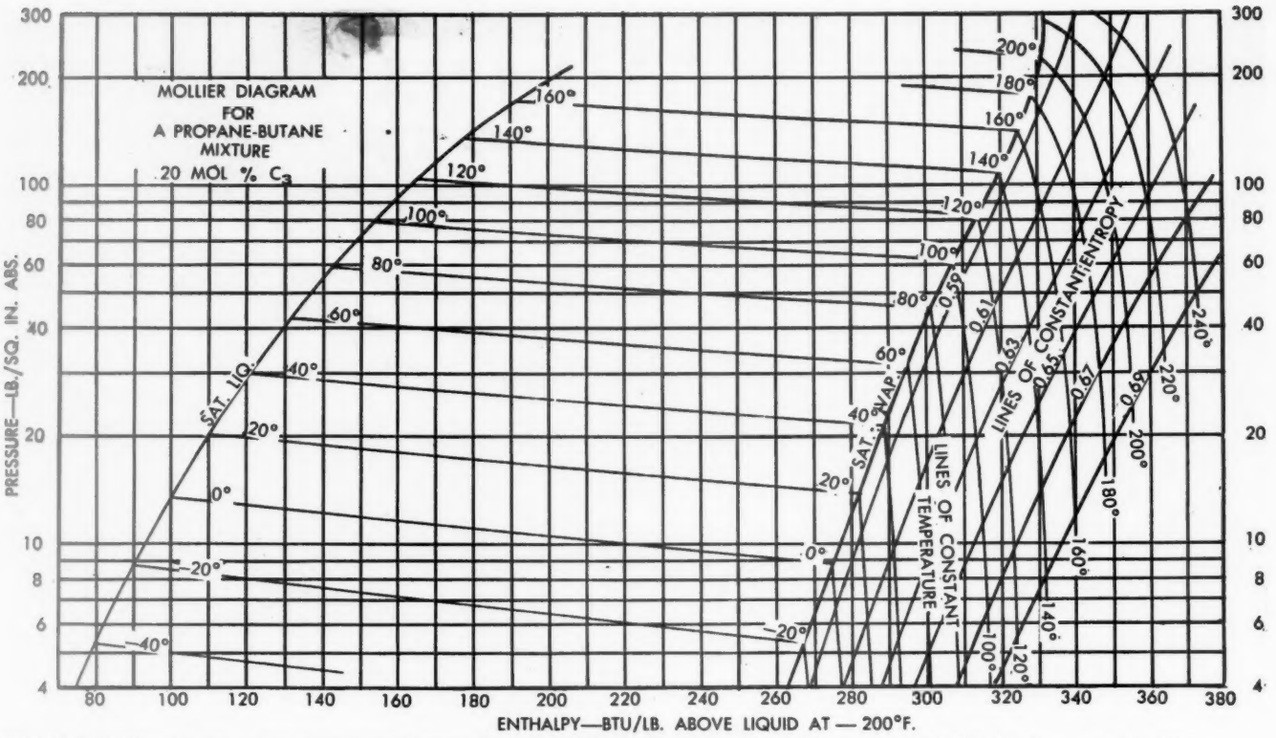


FIG. 20. Mollier diagram for a propane-butane mixture (20 mol per cent C_3—80 per cent mol C_4) (References 20, 3)

from the pure hydrocarbon charts are established by the following assumptions, which appear to be justified by accurate heat balances on plant equipment.

Liquid mixtures. (a) Enthalpies for components whose critical temperatures are above the temperature of the mixture are read from the saturated liquid curves of the pure hydrocarbons at the temperature of the mixture; (b) components whose critical temperatures are below the temperature of the mixture are assumed to be at a hypothetical liquid state, enthalpies being read from the extrapolated vapor pressure line of the pure hydrocarbons at the temperature of the mixture.

Vapor mixtures. (a) Enthalpies for components whose vapor pressures are higher than the pressure on the system are read from the pure hydrocarbon plots at the temperature and pressure (total, not partial) on the system; (b) components whose vapor pressures are lower than the pressure on the system are assumed to be hypothetical vapor and their enthalpies are read from the saturated vapor curve of the pure hydrocarbons at the temperature of the mixture.

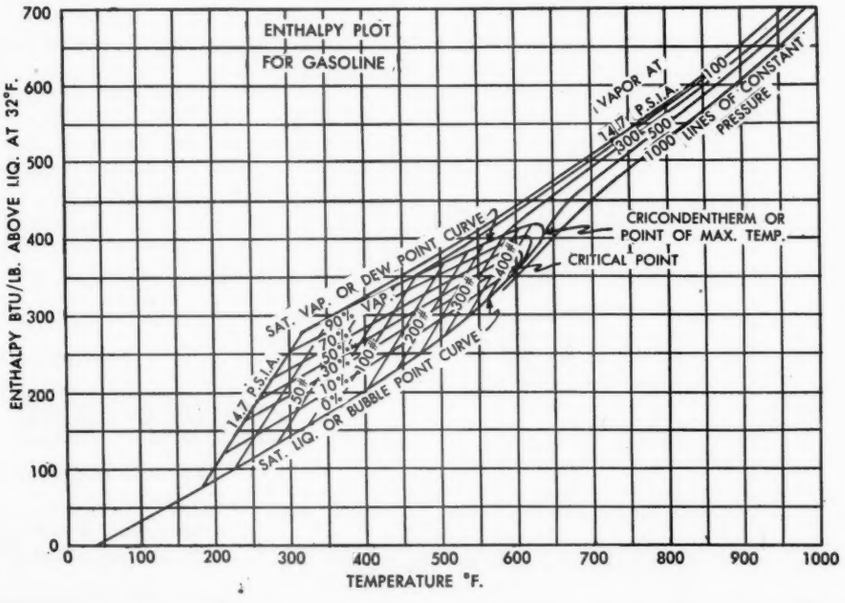
Additivity. The enthalpies of the components of a hydrocarbon mixture are assumed to be additive.

In applying this method to the computation of enthalpies for mixtures, it is necessary to know the phase conditions that may be estimated by the phase equilibria methods outlined above. Following this procedure for entropies and enthalpies, the Mollier diagram shown in Fig. 20 was prepared for a propane-butane mixture. This and similar charts are useful in making refrigeration calculations.

The above method of computing entropies and enthalpies for hydrocarbon mixtures is one of three methods that may be used, the other two methods being: (1) The pseudo-critical method, and (2) the equation of state method. The pseudo-critical method is readily applied by means of the correlations and equations presented above. In this method the pseudo-critical for the mixture is used in estimating the isothermal effect of pressure on the entropy and enthalpy of the mixture. The latent heat of vaporization is computed by the entropy function method described above. Phase conditions are likewise required for the mixture in this method. The equation of state method is analogous to the equation of state method mentioned above for estimating phase-equilibria conditions for non ideal solutions. This method is complex and of little practical value except to spot check enthalpies and entropies computed by the other methods.

In preparing the Mollier diagram for propane-butane (Fig. 20) and other sim-

FIG. 21. (References 1, 9, 12, 14, 24, 33)



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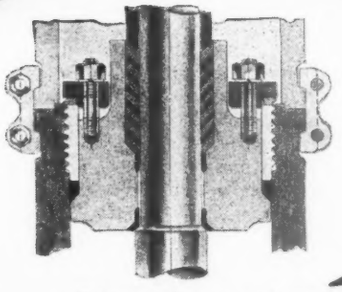

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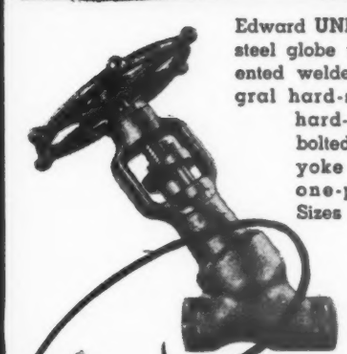

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ilar diagrams, the pseudo-critical and the equation of state methods were used to check several points. Agreement was satisfactory. Fig. 21 is an enthalpy diagram for gasoline prepared by the pseudo-critical method, empirical methods being used to estimate the phase-equilibria conditions. Similar diagrams may be prepared for any hydrocarbon mixture or petroleum fraction by the same method. The preparation of such charts is desirable when many calculations must be made for the same stock.

The component enthalpy diagrams may be applied to make net heat balances or total heat balances. In making net heat balances, i.e. net enthalpy change for each component in going through the system, the datum point is not important. With total heat balances, the datum point for all components should be the same.

● **Hydrocarbon reactions and combustion.** Thermodynamics is a useful tool in studying hydrocarbon reactions. It may be used to estimate the driving force and equilibrium of a given reaction, and thus predict whether or not a given reaction will occur and the conditions that are most favorable to it. By a combination of thermodynamics and kinetics, the equilibrium distribution of products may be estimated. Thermodynamics may also be used to compute the heat absorbed or liberated for reactions. Table 5 presents the fundamentals of applying thermodynamics to chemical reactions.

The heat of reaction is the quantity of heat that must be added or removed to make the reaction take place. This heat is not recoverable. When heat must be added the reaction is "endothermic" and when heat is removed the reaction is "exothermic." Cracking is endothermic and polymerization is exothermic. By the combination of thermochemical equations, heats of reactions for hydrocarbons may be calculated from the heats of formation of the reactants from carbon and hydrogen. Heats of formation can be evaluated by a similar combination of heats of combustion. Heats of reaction may also be determined experimentally in a calorimeter.

Because of the many side reactions that usually occur in hydrocarbon reactions, it is difficult to correlate experimental heats of reaction unless the theoretical method, based on heats of combustion, is also employed. The heat of reaction for hydrocarbon reactions depends upon the type and quantity of hydrocarbon molecules made in the reaction. From a study of theoretical heats of reactions and the compositions of products from various reactions, the diagram shown as Fig. 22 was constructed to show the relative effects of the various factors on the heat of reaction. This plot is for reference only and not intended to be of sufficient accuracy for design calculations.

In making a heat balance on a hydrocarbon reactor, it is important to be consistent in the enthalpies of reactants and products and the heat of reaction used. A recommended method is to make a net heat balance, i.e. compute the amount of heat required to heat the feed up to the reaction conditions, compute the heat of reaction at reaction condition, and compute the change in enthalpy of the products from reaction temperature to exit temperature. The algebraic sum of the heat quantities gives the heat balance. This method avoids computing the heat quantities of all hydrocarbons involved above an arbitrary and meaningless datum point and therefore avoids possible errors. In making these computations care should be taken to have the heat of reaction corrected to the reaction temperature. This point is emphasized because heats of reaction are often given at "standard states."

Enthalpies of flue gases are used in making furnace and catalyst regeneration calculations. Flue gas enthalpies

CHEMICAL REACTION EQUILIBRIUM

HEAT OF REACTION

$\left(\frac{\partial \Delta H}{\partial T}\right)_P = \Delta C_P$ FROM WHICH

$\Delta H_2 - \Delta H_1 = \int_1^2 \Delta C_p dT$

$C_p = A + BT + CT^2$; FOR EACH COMPONENT. ADDING CONSTANTS A,B,C ALGEBRAICALLY GIVES

$\Delta C_p = \Delta A + \Delta BT + \Delta CT^2$ FOR MIXTURES

SUBSTITUTING AND INTEGRATING

$\Delta H = \Delta H_0 + \Delta AT + \frac{1}{2}\Delta BT^2 + \frac{1}{3}\Delta CT^3$

FREE ENERGY OF REACTION

$\frac{d\left(\frac{\Delta F}{T}\right)}{dT} = -\frac{\Delta H}{T^2}$

$\Delta F = \Delta H_0 - \Delta AT \ln T - \frac{1}{2}\Delta BT^2 - \frac{1}{6}\Delta CT^3 + IT$

INTEGRATION CONSTANT I EVALUATED FROM ΔF AT KNOWN TEMPERATURE AND ΔS FROM THIRD LAW AND FOLLOWING EQUATION

$\Delta F = \Delta H - T\Delta S$

EQUILIBRIUM YIELDS

EQUILIBRIUM CONSTANT FROM ΔF

$\Delta F = -RT \ln K_f$

LAW OF MASS ACTION

$aA + bB = cC + dD$

$K_p = \frac{(\text{CONC C})^c (\text{CONC D})^d}{(\text{CONC A})^a (\text{CONC B})^b}$

FOR VAPOR PHASE REACTIONS PARTIAL PRESSURES AND ACTIVITY COEFFICIENTS MAY BE USED AS FOLLOWS

$K_p = \frac{K_f}{K_\gamma} = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$

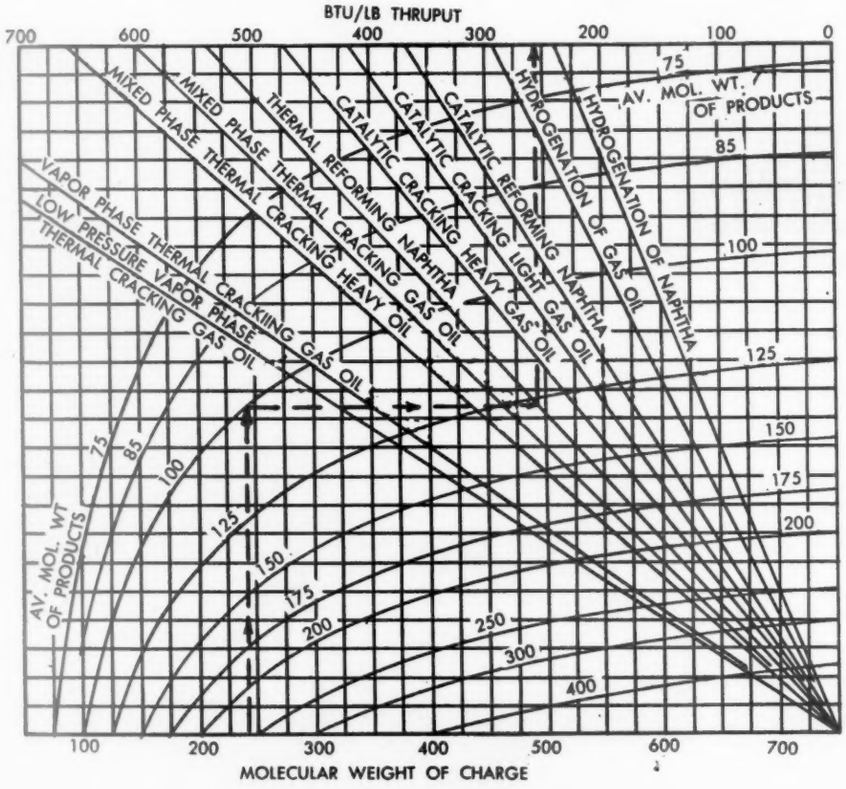
$K_\gamma = \frac{(\gamma_C)^c (\gamma_D)^d}{(\gamma_A)^a (\gamma_B)^b}$

DATA REQUIRED

1. HEAT CAPACITIES
2. HEATS OF FORMATION
3. ABSOLUTE ENTROPIES
4. VAPOR PRESSURES AND FUGACITIES

TABLE 5. Equation for the application of thermodynamics to chemical reactions

FIG. 22. Approximate endothermic heats of reaction



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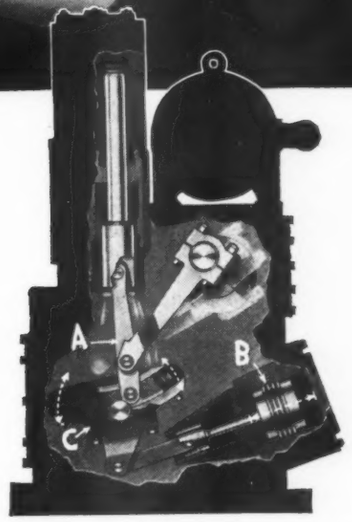

Power is supplied to plunger by connecting rod through a link (A). Length of plunger stroke is controlled by piston (B) which positions stroke transformer (C). In zero stroke position, the link has a pendular motion and the plunger is stationary. To increase delivery, the stroke transformer (C) is tilted, so that the link motion is given a vertical component which actuates plunger through any travel up to full stroke.

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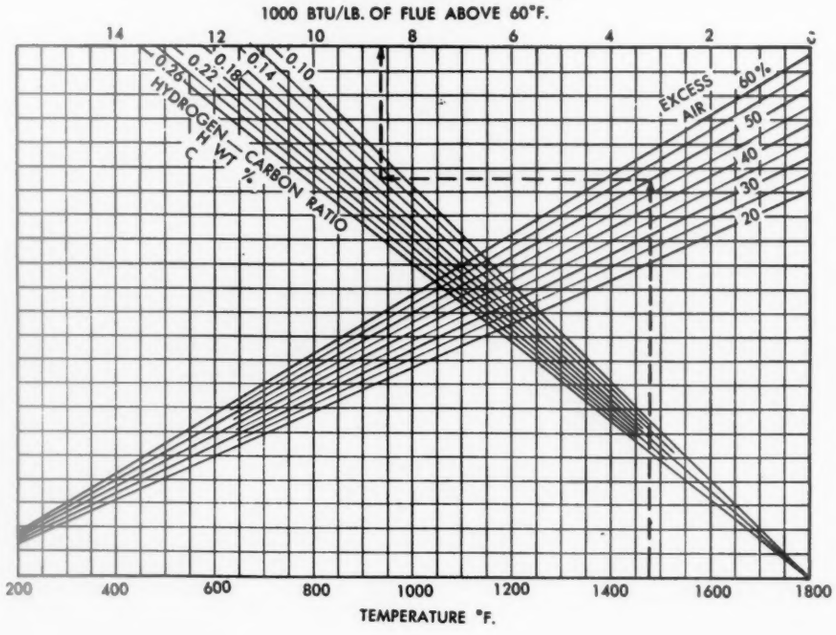
FIG. 23. Enthalpy of flue gases



depend upon the composition of the fuel and the amount of excess air used. For hydrocarbon fuels, such as gas and oil, the flue gas enhalpies can be plotted as a function of hydrogen/carbon ratio and per cent excess air. Such a plot is presented as Fig. 23. The use of this graph is obvious.

● **Process applications.** As an example of the applications of thermodynamics to hydrocarbon process design, a fluid catalytic cracking unit with fractionation and vapor recovery facilities may be considered. In this process, oil is cracked in the presence of a fluidized catalyst, which circulates through the reactor and regenerator system picking up heat in the regenerator, where the coke is burned off by air, and liberating this heat in the reactor by transfer to the oil. The cracked products are fractionated, the light ends and gasoline going to a vapor recovery unit, via compressors and pumps, to be separated into desired products.

Thermodynamics is involved at the following points: (1) Turbo air blower design, (2) regenerator heat balance, (3) reactor heat balance, (4) fractionator phase-equilibria and heat balance calculations, (5) product gas compressor design, and (6) phase-equilibria and heat balance calculations in the design of the vapor recovery facilities.

● **Acknowledgment.** This discussion has covered many subjects. Contributions to our knowledge in this field have been made by many investigators. No attempt has been made to discuss these investigations in detail. Such a discussion would add materially to the length of this paper. Acknowledgment is made by including a list of literature references and by indicating on the cut line of the tables and figures where the work of others or previous publications of this author were used.

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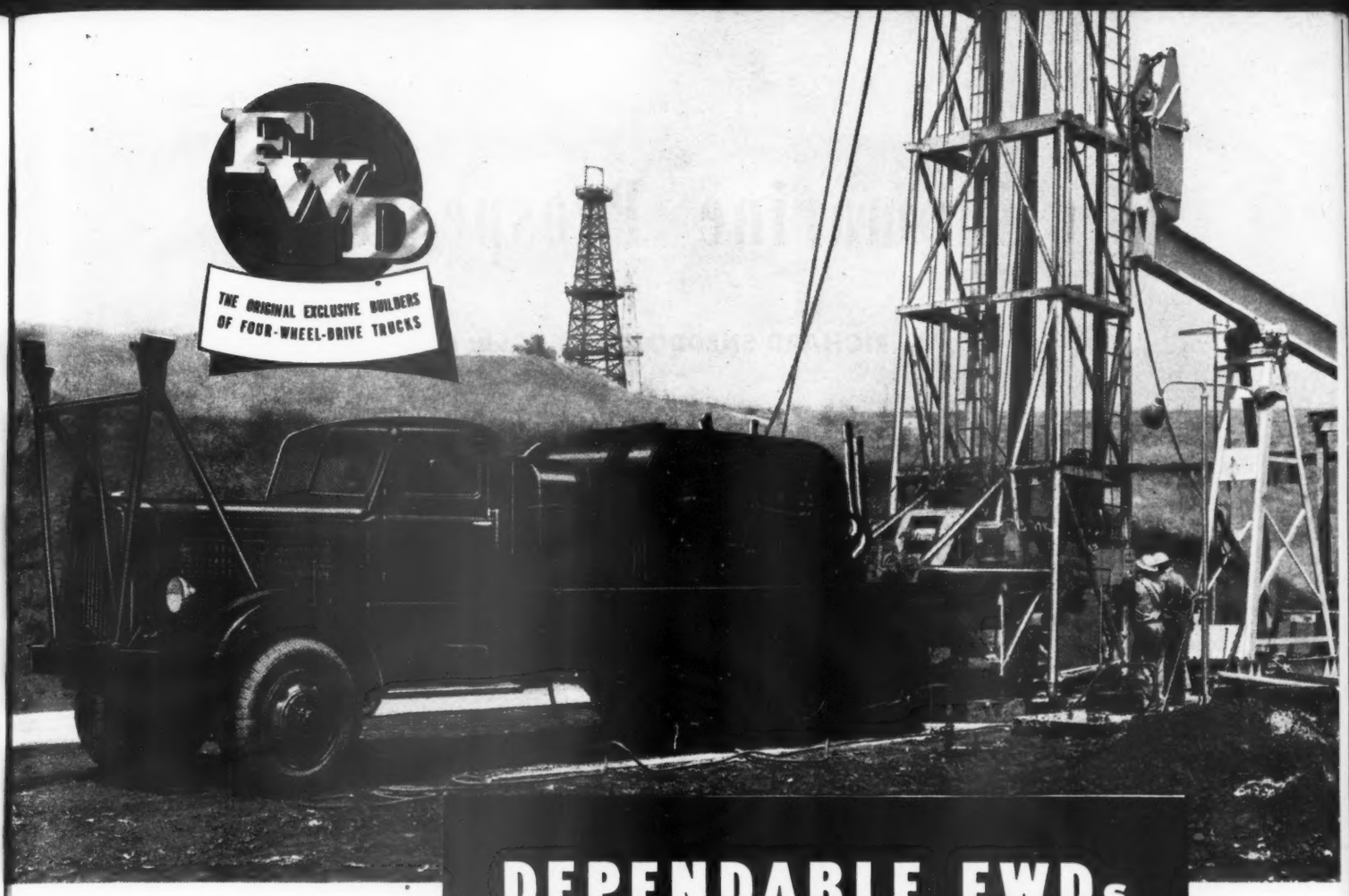
Spanish for new employes in Venezuela

The Houston office of the department of commerce has been advised that one of the larger American oil companies has opened a school for the indoctrination and orientation of new employes brought from the United States to Maracaibo, Venezuela. The first class had 60 students and nine teachers, and extended over a period of eight weeks of 40 hours each.

Using the most advanced methods, all the teachers give Spanish lessons to small groups for five hours each day. Besides the teaching of Spanish, there are lecture and field trips on the following subjects: Company organization and operation; basic labor policies; economic, political, and social life in Venezuela; history of Venezuela and the petroleum industry.



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FWD Model M 6x6 Oil Well Servicing Rig shown in typical oil field operation. The rig telescopes down over the truck for over-the-road transport.

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THE FOUR WHEEL DRIVE AUTO CO., Clintonville, Wisconsin, U.S.A.

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"More Power on More Wheels!"

Submarine Prospecting

By **RICHARD SNEDDON,** *Pacific Coast Editor*

TESTED early in the month of April in Los Angeles harbor and now in actual use on the Gulf Coast by Union Oil Company of California is the latest thing in bathyspheres. The device and the fundamental purpose of its operation are not exactly new, but it is understood that this particular model, incorporates some quite novel ideas—one being that the operator can in emergency release the heavy base of the apparatus allowing the cylinder to bob to the surface. The principal function of the device is to carry an operator to the bed of the ocean in shallow waters, so that he can take gravimeter readings from a permanently level surface, rather than from the deck of a boat, which rises and falls with every motion of the water. In this particular area it will be used to locate salt domes, phenomena that are frequently associated with oil deposits. The method employed will simply be to move the cylinder from place to place while the operator determines gravitational pull at each location. The salt domes are indicated in the Gulf Coast region by so-called minima readings, revealing the presence of formations of lesser density.

EXCLUSIVE

Bauers in the diving bell he designed for exploratory work in shallow waters off the Texas and Louisiana coasts. It was built under direction of Dr. J. J. Jakosky, consultant, for Union Oil Company of California, which has put it to use.

Bob Bauers, left, designer of the new type diving bell, is seen with A. C. Rubel, vice president of Union Oil Company, as they await the boat that will take them out into deep water to conduct experiments. Some of the instruments and equipment involved are shown lying on the wharf.

Three feet in diameter and five feet high, the chamber and its accoutrements were developed and assembled by Engineer Bob Bauers, under the direction of Dr. J. J. Jakosky, consultant. The bell is made of ½-in. galvanized plate, weighs 1500 lb., and is capable of withstanding the pressure at a depth of 100

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1. The hydraulic "cushion" effectively absorbs the jars, jerks and strains.
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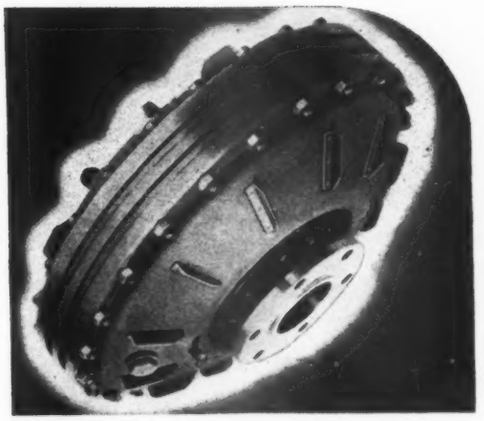
3. The hydraulic drives provide a smooth, flexible flow of power . . . combine the advantages of steam with the economy of the gasoline or diesel engine.

Results: Less time out and less money spent for maintenance and repairs . . . added working life for lines, cables and the entire rig. These proved advantages—and more—are common to all Twin Disc Hydraulic Drives . . . Hydraulic Torque Converters,* Hydraulic Couplings and Hydraulic Power Take-offs. That's why, when you count any one of these Twin Disc units a part of your rig, you can count on more feet drilled . . . faster . . . *cheaper!*

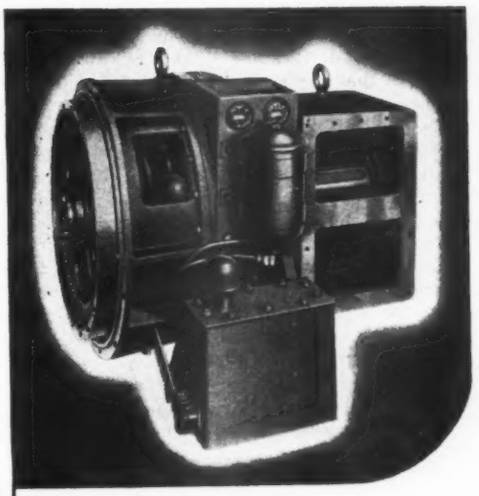
Write the Hydraulic Division today for complete specifications. Ask for Bulletins No. 135-A (torque converter) and No. 136 (couplings and power take-offs). TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

**Lysholm-Smith Type*

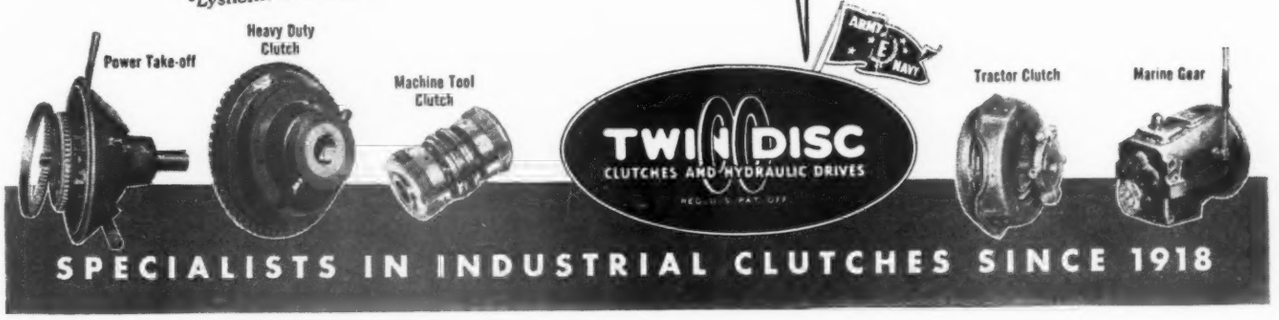


Hydraulic Coupling

Hydraulic Power Take-off



Hydraulic Torque Converter



The operator fits snugly inside the bell. He is leaning over reaching for the spider that releases the base when unscrewed.

It is indicative of the scientific and progressive mind that when the test took place at Los Angeles, all three principals, Dr. Jakosky, consulting geophysicist, Bob Bauers, engineer, and A. C. Rubel, vice president of Union Oil Company, were equally anxious to make the first dive. The only fair way to settle the argument was to flip a coin, which was done. The result was that Bob Bauers, the designer, was elected for the initial trip. After being locked in, the bell was lowered with no delay or difficulty some 20 ft. to the muddy bottom of the harbor, where, remaining in constant telephonic communication with those above, the operator tested the various items of equipment and found everything performing according to schedule. Upon his return to the surface, "Cy" Rubel climbed in, and although he fitted a little more snugly into the vessel for some unaccountable reason, nevertheless, made a very successful jaunt into the depths, and coming out of the bell at the conclusion, casually remarked, "Didn't see a single mermaid."

On a subsequent run, Bob Bauers tested out the base release, and the deck crew could distinctly hear his puffs and muttering as he turned the spider to free the bell. This test, too, achieved all that was expected. When the base and the chamber parted company, the latter bobbed to the surface in record time, wallowing like a tired porpoise until it could be taken aboard. In every respect, indeed, the experimental trip was com-

ft. To this, a base weighing 1250 lb. is fastened by a screw working through a packing gland. It has a spider on the inside so that the operator may release the base and permit the bell to rise to the surface, if that should become expedient. The shell is provided with two small portholes, through one of which observations may be made, whereas through the other a spotlight is focused on the area under examination.

Interior equipment consists of an oxygen bottle with pressure gauges, and a meter for determining the oxygen content of the air. Under the seat is an air purifier, soda lime and calcium chloride being the active agents, and circulation is maintained by means of a small fan. The entire interior is upholstered to the top with seat leather, and a safety belt further saves the operator unnecessary jostling. A telephone is available for communication with the surface, with the power and telephone line being threaded through the core of the cable holding the bell. On the seat is what *Time* magazine described as "a cramped geologist," and certainly, once inside with the top clamped down, and a gravimeter on a stand between his legs, the operator doesn't have much room to make anything other than essential motions. And he wouldn't need to be addicted to claustrophobia. Sufficient inside room is available, however, in which to carry on everything that the apparatus was designed to accomplish.

R. L. Parker, Jr., Union Oil Company's patent division, gives Bauer, inside the bell, the control head for the oxygen supply.

Longer Life

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No Gas Locking

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G-B EXPAN-SEAL PLUNGER

For Oil Well Pumps

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Actual case histories show the new G-B EXPAN-SEAL Plunger is outwearing and outperforming all other types of plungers with plenty of hard money statistics.

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In addition to its record-breaking production between pulls, G-B EXPAN-SEAL rings require no oversize cups, thus reducing your inventory.

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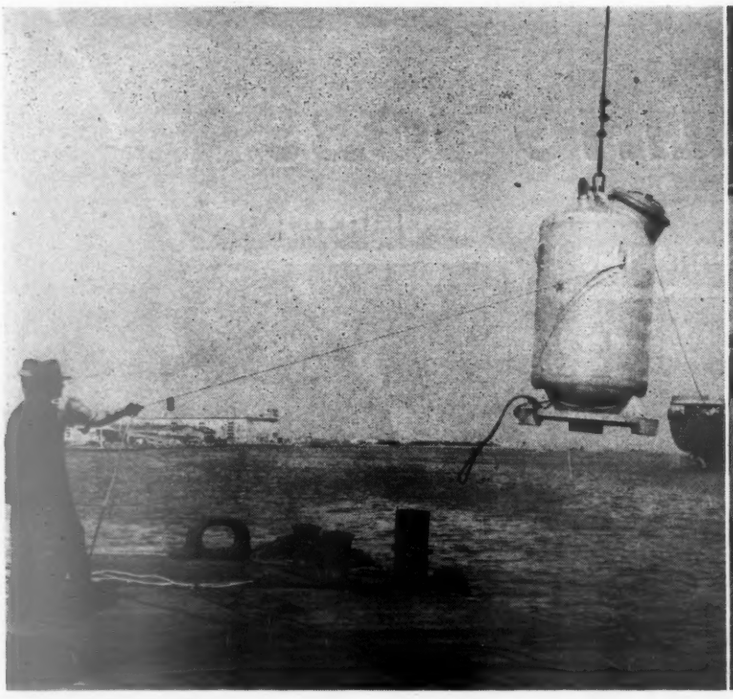
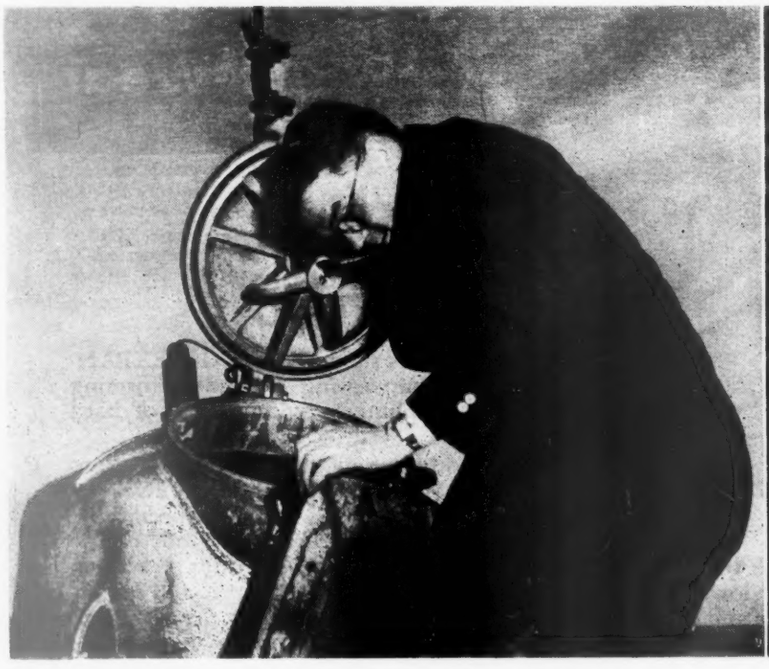


Diving bell with operator inside is lowered into the ocean. Detachable base section is shown; also the telephone line, which is threaded through the cable holding the bell.

Rubel talks with Bauers, who is inside the bell 20 ft. under water. Slightest sounds made by operator are clearly audible on the surface.



Getting through the manhole in the exploration diving bell is easier than it looks, as Rubel demonstrated when he took a trip to the bottom of Los Angeles Harbor. He is shown here coming out. Didn't see a single mermaid, he said.

When freed from the detachable base, the bell bobs to the surface and stays until it is taken aboard. The base is a safety feature, permitting operator to come to the surface.

pletely successful. There was no indication of leakage; all the equipment functioned exactly as it was designed to do, and the practicability of the assembly as well as the effectiveness of its safety features were thoroughly established. It might also be mentioned that a prior submersion of the empty bell to a depth of 160 ft. resulted in only a very minor leakage around the packing gland.

A fishing boat has been especially adapted and equipped with the necessary machinery to handle the bell properly under every foreseeable condition. It is not intended that it should be lifted on deck for every move, but, on the contrary, that it should simply be made fast and towed from one location to another. Union Oil Company intends to explore certain submarine lands along the shores of Texas and Louisiana, where, according to available data, there may be found extensions of already producing oil-bearing formations. ★★★

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To its broad line of oil field engines, Continental Motors has added 5 Diesel engines of advanced design. These new Continental Diesels, with a range of 20 to 130 horsepower, have a "Cushioned Power" combustion chamber which reduces peak pressures and results in cleaner burning and minimum fuel consumption.

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POWER BY

Red Seal

Engines

CONTINENTAL

Look for the Continental Red Seal; It Identifies the Finest in Every Field of Power

Heavy Duty Propelling and Steering Device Aids in Marine Operations of Oil Industry

EXCLUSIVE

Few lands, no matter how remote, are escaping the minute scrutiny of oil crews delving for the rich deposits of petroleum under the crust of the earth, or beneath the waters of the sea. It is an infinite search going on and on with discoveries and developments merely pauses—never goals achieved.

Many oil companies have also turned their efforts to extending the productive area of fields already producing, especially those fields that because of any one of numerous reasons were not fully exploited. This lack of previous development has been due in many cases to the unavailability of highly specialized marine equipment.

The needs of marine oil development and producing operations in coastal fields are so alien to common marine commercial uses that for the most part new equipment has to be devised for each specific job. A means of overcoming several of the most important obstacles to marine petroleum development and production are seen in the application of a heavy-duty propelling and steering mechanism[1] of unique design and construction.

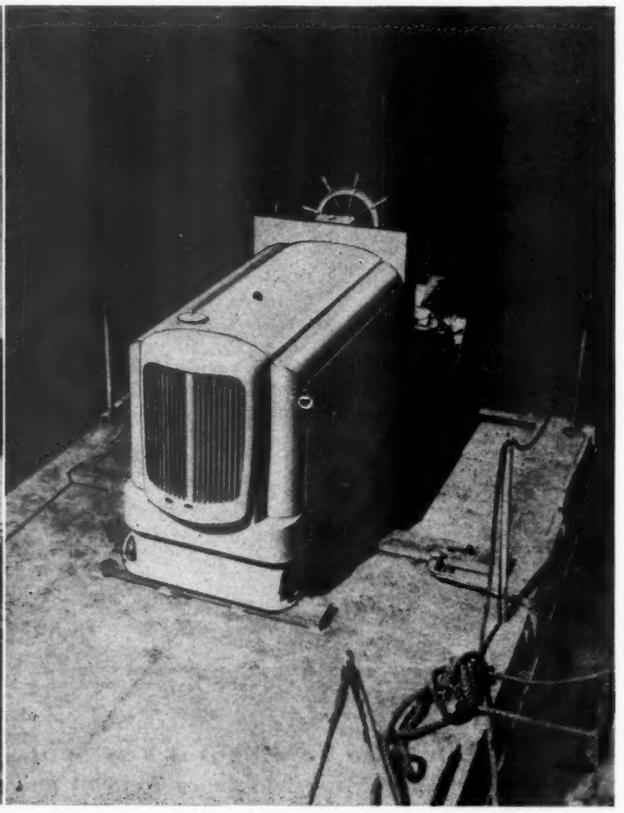
Any portrayal of these marine problems necessarily radiates around shallow water operation with power, maneuverability, and on-the-spot maintenance playing the leading roles. In many cases exploration crews must navigate strange waters that never before lapped against modern hulls—waters filled with shallow, treacherous perils where at one second power is all-important; at the next instant ultra-maneuverability is most needed. Over these same waters when the go-ahead signal is flashed, heavy drilling and pumping machinery must be moved, and constant supply lines must be established and operated on regular schedules. Such work calls for the best in equipment delivering a high degree of efficiency.

As may be noted by the accompanying illustrations of the various models, this mechanism is of unusual design in contrast to conventional power and steering equipment. Originally designed and developed as the giant outboard propulsion units for the Rhino Ferries and Rhino Tugs, these diesel or gasoline-powered units are in continuous commercial service throughout the world. The units are instantly adaptable to many types of craft including barges, lighters, drilling and derrick barges, tugs and towboats, and personnel craft. With models ranging from 20 hp. to 330 hp. they are available for many phases of marine operations and, in the smaller horsepower sizes, they are also portable.

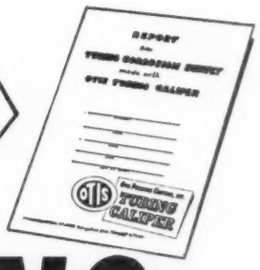
[1] The Murray and Tregurtha "Harbormaster."

Model with 165-hp. diesel, mounted on utility pontoon barge. Excellent craft for coastal and river operations.

Another view of a Harbormaster on a barge, this time with 110-hp. diesel motor. Shallow water is no barrier.



the INSIDE STORY ⇨



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New OTIS TUBING CALIPER

The OTIS TUBING CALIPER, run under pressure on a steel measuring line, mechanically measures the maximum depth and location of corrosion pits and indicates the minimum wall thickness. Calipering is accomplished by six spring-loaded feeler arms pressed against the tubing wall and connected to a stylus which records their movement on a metal chart. Photostats of the charts, recording up to 2,250 feet of tubing each, are combined with a comprehensive report on each well and delivered to the operator. Surveys of 10,000 feet of tubing have been completed in a single day. The general condition of the tubing can be quickly analyzed or each joint studied individually.

The portion of a chart shown above is the actual caliper log of a corroded section of tubing. Corrosion is indicated by erratic lines having peaks in proportion to the extent and depth of the corroded area.

Otis Pressure Control crews, consisting of an engineer, and a wire line specialist experienced in installing and maintaining sub-surface controls under pressure, are running the OTIS TUBING CALIPER.

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TUBING CALIPER

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Official U. S. Navy photo.

Mobile derrick lowers model with 110-hp. diesel in Seabee operations for development of Alaskan oil fields.

Machine-equipped workboat showing elevating mechanism at 90 deg. Engine has 110 hp., is gasoline powered.

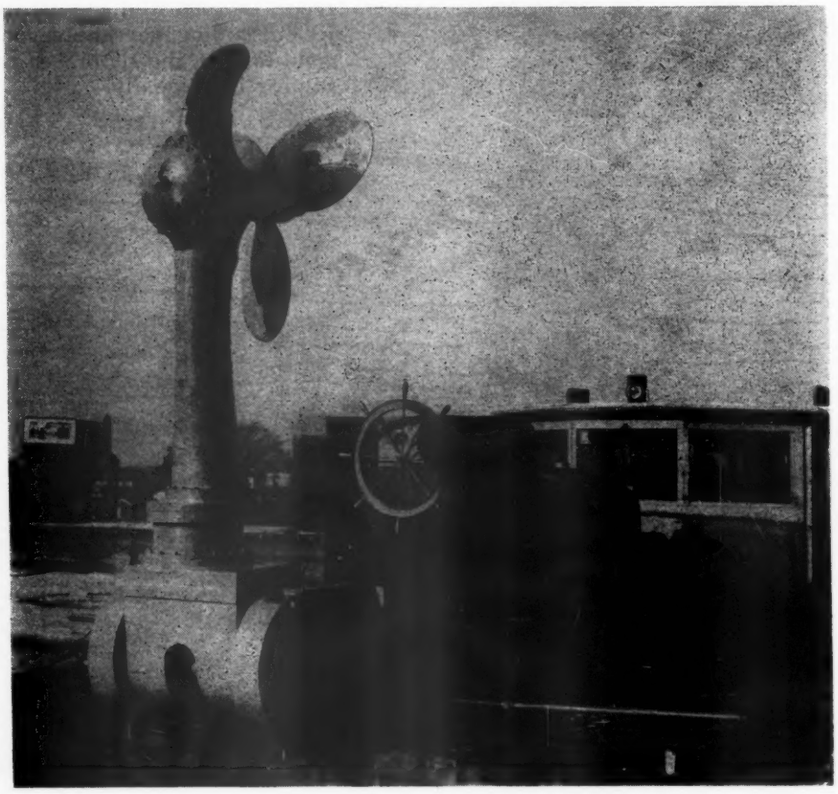
Because of compactness of design and manufacture, the portability of many models makes it possible for them to be quickly and easily transferred from one craft to another. Hence, in many instances, especially in the oil fields, a single unit can propel and steer many craft during operations, doing the work of several conventional immobile power plants. Although this feature is a valuable one in oil operations, yet portability and adaptability are not so important as the ability to provide dependable, efficient power. Thorough tests during continuous commercial operations, plus those at the plant, have demonstrated that all models continuously deliver maximum thrust per horsepower.

There are reasons for this high efficiency. All models are compact and rugged, and set up for immediate operation on the factory floor with precision and as close tolerance as is humanly possible. The units also operate this way. No installation adjustments are necessary—no fitting to the designs of a particular craft—because they are manufactured with extreme precision and made to operate efficiently.

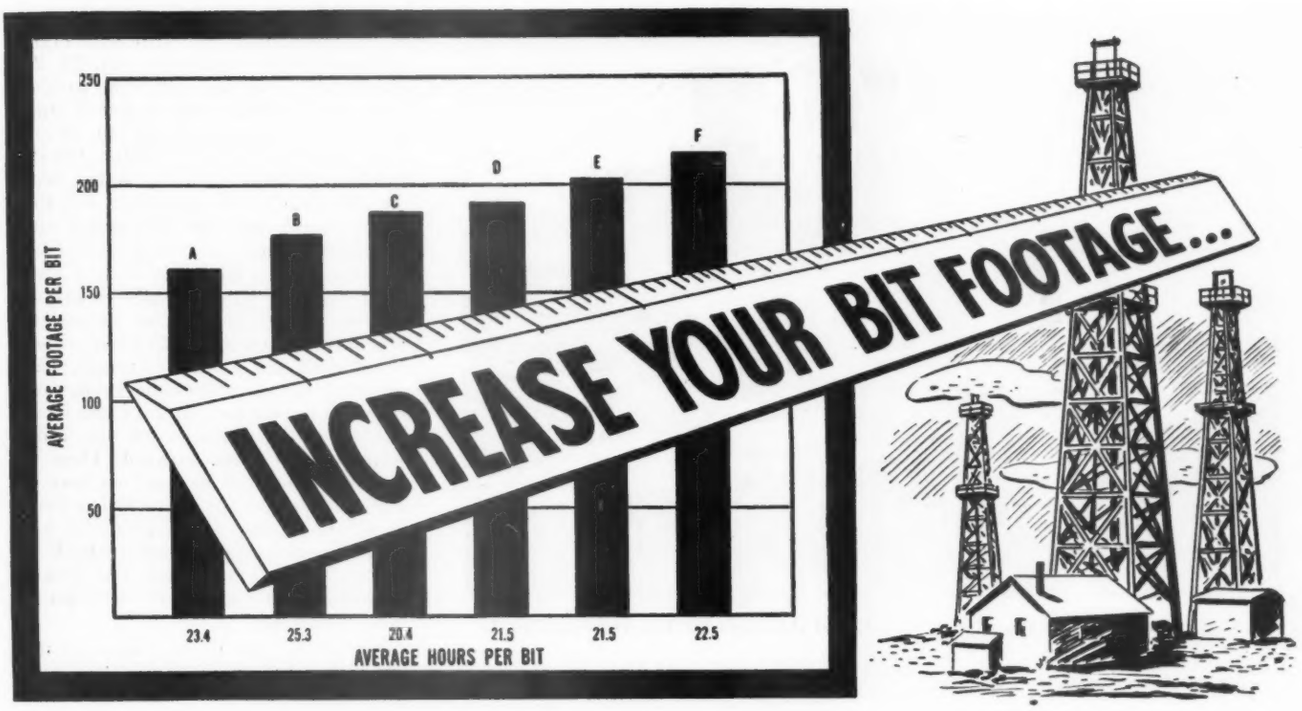
In the majority of cases they are set on or imbedded in the stern of the craft so that the inevitable and costly "working of the boat" has absolutely no effect on thrust efficiency.

The large wheel of the Harbormaster, in normal operations, sets in a flow of "Solid water." This factor gives greater efficiency and, because of the assembly design, the unit gets a bigger bite into solid water, hence more thrust efficiency. Moreover, all units steer by the thrust of the propeller itself, thus eliminating the rudder. According to a consensus of naval designers and architects, the loss of thrust efficiency due to the rudder is anywhere from 3 to 10 per cent.

Maintenance economy and efficiency is one of the supreme "musts" so far as the petroleum engineer is concerned, and these requirements are achieved by the



Same powered model, the O-2, in a different type workboat showing 180 deg. elevating mechanism. The apparatus is able to hold positions against current and tide.



with *Aeroflo and Quadrafos*

Shown in the table above is the average bit run time and footage of six representative wells drilled in one important southwestern field. These figures indicate the importance of protecting bits through careful mud control.

Here AEROFLO* drilling mud conditioning compound and QUADRAFOS* (Sodium Tetraphosphate) can help to secure more effective footage per bit and reduce drilling time, costs and trouble. AEROFLO is highly effective in maintaining the correct viscosity of drilling mud, especially in deep wells and under difficult conditions. It often gives satisfactory results in cases that otherwise could be handled only with difficulty or not at all. It increases the effectiveness of phosphates in salt cut muds, in muds that do not respond to phosphates and where high temperatures cause rapid thickening. QUADRAFOS produces good results where conglomerate, sand, silty shales are drilled and the formation does not provide sufficient colloidal material. It renders inactive such materials as calcium and magnesium compounds, and controls the strength and rate of gel formation caused by dispersion, heat and salt water. Cyanamid Technical Service Representatives are prepared to provide "on location" assistance in working out your problems. For full information write, wire or call American Cyanamid & Chemical Corporation, 229 Shell Bldg., Houston, Texas, or Azusa, California.

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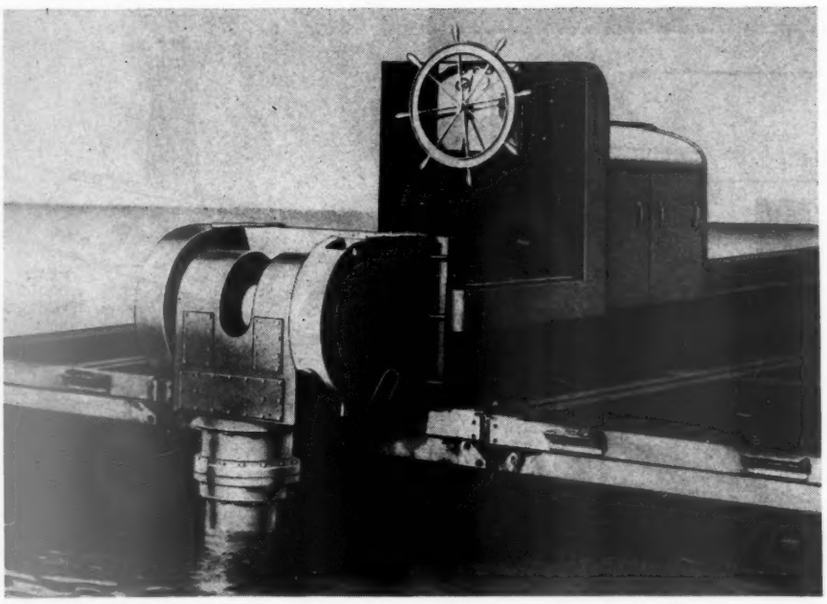

Mounted on a utility pontoon barge this Model 0-6 machine has 165-hp. diesel.

exclusive, patented M&T 180 deg. elevating mechanism, which allows the operator to elevate by power the entire submerged assembly, upward and backward to any degree he desires, out of water and directly overhead, if necessary. This item assures the elimination of dry-docking, beaching, or diving repairs due to damage or need of service to any part of the propelling and steering equipment.

The 180-deg. elevating mechanism answers another problem, namely that of operating with safety and economy in shallow and dangerous waters. By means of this mechanism the entire submerged section can be elevated to, say, 20, 25, 30, 35, up to 45 deg., retaining propulsion and steering control. The feature permits the engineer to operate in any water in which his vessel itself will float. Obviously, some efficiency is lost with the elevation of the propeller, but this loss is considerably less than is now customary with guards, nozzles, etc.

Every unit is equipped with a steel shear pin that automatically shears off the instant any part of the submerged assembly strikes an underwater object of sufficient size to cause damage. This automatic action allows the submerged assembly to ride free, upward and backward over the obstacle, all the while propelling the craft forward. There is no loss of forward motion, nor loss of time. As soon as the obstacle has been passed, the thrust of the propeller will push the submerged assembly back to the usual operating position, and it takes but a minute to insert a new shear pin—while under way.

One other remarkable feature of the unit is that the operator can steer with full power in any direction, giving 360-deg. maneuverability. This is possible because the vessel equipped with the mechanism steers by the thrust of the propeller itself, and simply by turning the wheel the propeller is turned in any direction and full speed in any direction becomes possible. ★★★

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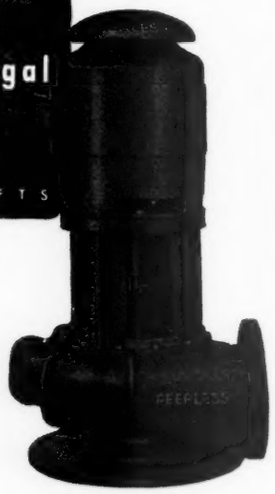
Vertical Centrifugal
Pumps
FOR SHALLOW LIFTS



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100 to 5000 g. p. m.
15 to 100 foot head

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SELECTIVE ACIDIZING INCREASES WELL CAPACITY

By PAUL L. SHELTON and J. M. CLARK

The Chicago Corporation

EXCLUSIVE

RECENT potential tests conducted on several wells located in the Carthage gas field of Panola County, Texas, have shown that selective acidizing of certain wells increases the total productivity as much as 50 to 75 per cent. Pay sands that ordinarily would have been mudded off or left unproductive have been brought in by selectively acidizing individual sections of the producing formation.

Most of the wells in this field are completed as dual producers in the Upper and Lower Pettit lime formations and have intial open flow capacities of 10,000,000 to 15,000,000 cu. ft. a day before acidizing. After treating the wells with an average of 5000 gal. of 15 per cent hydrochloric acid, the potential of the wells for each formation is increased considerably, averaging about 50,000,000 cu. ft. a day. In some cases, potentials have been reported as high as 200,000,000 cu. ft. a day.

Comparative analysis of the Schlumberger logs of various wells in the field generally indicated one fairly large producing section in each of the two Pettit formations; however, the Schlumberger logs of several wells recently completed showed two separate and distinct sections in the Lower Pettit formation in addition to the regular pay zone found in the Upper Pettit. This presented a new problem inasmuch as the wells were originally intended to be completed as dual gas producers, and the usual method of completion made no provisions to utilize more than two producing sections.

Past experience had shown that treating individual sections by killing the well and mudding off each acidized section does not increase the total volume when the well is finally brought in for production. Once a section has been acidized and then mudded off, the effects of the treatment are reduced to such an extent that no material benefits are realized.

Assuming that it was probable for the acid to break down the upper section of the formation and not affect appreciably the lower section, due to the possible existence of a mud cushion and greater resistance in the lower section, it was decided to complete the well so that each section with a definite break could be acidized and tested separately without killing the well. This was accomplished effectively by the use of two packers and two side-door chokes, as illustrated by Fig. 1, appropriately spaced in the hole between the three pay zones so that the middle pay zone was sealed off completely from the upper and lower sections. Then, through a series of choke changes, as described below, acid was spotted directly into each pay zone.

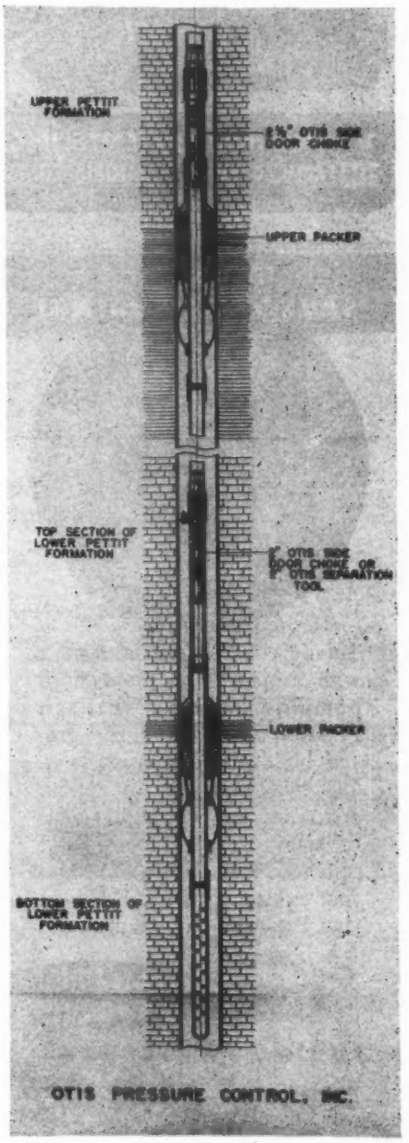
Upset tubing, 2 in. in diameter, served as a spacer between the two packers and 2½-in. upset tubing was used for the producing string. The Type M separation tool,* Fig. 3, used in this special set-up was designed with two sets of opposing cups that tend to give a positive seal against pressure above and below the tool. This particular tool was set in the regular 2-in. side-door choke* landing nipple and the lower section of the formation was sealed off completely. Due to the construction of the tool, the middle, or top section in the Lower Pettit, could produce through the ½-in. ports in the landing nipple as shown by the arrows in Fig. 3. A 2½-in. side door choke,* Fig. 2, separated the two formations above and below the top packer.

The Upper Pettit was acidized first by pumping directly into the annular space and forcing the acid in the formation through the perforations in the pipe. As soon as the acid in the annular space was displaced by water, the casing wing valves were closed, and acid was pumped down the tubing. The acid was forced out the side ports in the 2-in. side-door landing nipple, through the casing perforations between the two packers, and into the formation. A good breakdown on both sections indicated an increase in the permeability of the limestone surrounding the well bore.

In order to acidize the lower pay, the bottom section of the Lower Pettit, it was necessary to pull the 2½-in. side-door choke and the 2-in. separation tool, replace the separation tool with a regular 2-in. side-door choke, and re-run the 2½-in. side-door choke. This arrangement sealed off the ½ in. ports in both the 2-in. and 2½ in. landing nipples, allowing the Upper Pettit to produce only through the annulus and the bottom section of the Lower Pettit to produce through the tubing, the upper section of the Lower Pettit being completely sealed off.

Before acidizing the lower section, an attempt was made to run a potential to determine the capacity of this particular section, so that a comparison could be made with the potential to be taken after treatment. It was impossible, however, to flow the well very long without the surface choke nipples becoming clogged

FIG. 1.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UPPER PACKER
TOP SECTION OF LOWER PETTIT FORMATION
2" OTIS SIDE DOOR CHOKE OR 2" OTIS SEPARATION TOOL
LOWER PACKER
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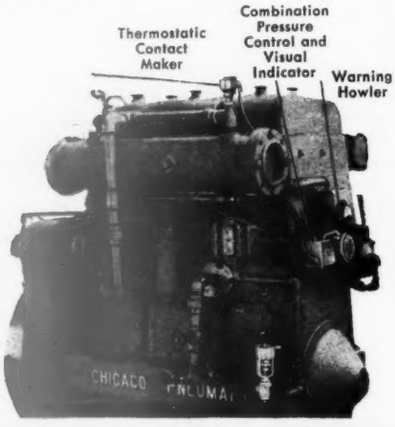

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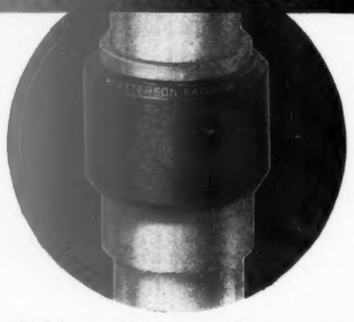

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with heavy drilling mud. This indicated clearly that the lower section of the well was still mudded off and probably would not produce much against the pressure of the upper section of the Lower Pettit.

Acid was then pumped down the tubing, out the perforated joint on the bottom of the string, and into the formation. A good formation breakdown was obtained and the spent acid reversed. This section of the Lower Pettit was completed through a ½-in. surface choke with a flowing pressure of 2100 lb. per sq. in.

It is of particular interest to note that the well was first washed in with all sections open and that the lower section failed to flow until acid was spotted directly into the formation by the special side-door choke arrangement.

The side-door chokes were pulled and the 2½-in. choke re-set, thereby separating the Upper Pettit from the Lower Pettit formation. Potential tests were taken with a dead-weight tester. Each section was tested separately, and the two lower sections were tested in combination before and after acidizing to determine the increase in volume. The results of these tests are listed below:

Pay zone	Potential before acidizing, M. cu. ft. per 24 hr.	Potential after acidizing, M. cu. ft. per 24 hr.
Upper Pettit formation	12,000	125,000
Top section of Lower Pettit	10,000	66,000
Bottom section of Lower Pettit	2,000	16,500
Lower Pettit formation (combined)	14,700	88,000

A study of the flowing pressures on a series of calibrated chokes showed that a complete separation of all pay zones was effected by the dual packer and side-door choke setting. A comparison of the results obtained on these tests shows that the sum of the potentials of the two individual sections of the Lower Pettit formation is about the same as the potential of the two sections in combination.

A net increase of about 25 per cent, or 14,500 M. cu. ft. per day, in the total open flow capacity of the Lower Pettit was obtained on this particular well by the selective acidizing procedures. On other wells in the field where this method was employed, the lower section of the Lower Pettit is estimated to contain a large part of the total proved gas reserve.

In most cases it was found that the lower section was either mudded off or too weak to be produced commercially, and yet this section appeared to be the richest in liquid hydrocarbon content after it was acidized. Since this method has been adopted, several wells have been brought in for production and completed in a similar manner. Improvements have been made in the method of completion that make the entire operation relatively simple. A special packer arrangement has been developed to facilitate the dual packer setting and, at the same time, to obtain a positive seal between the producing formations.

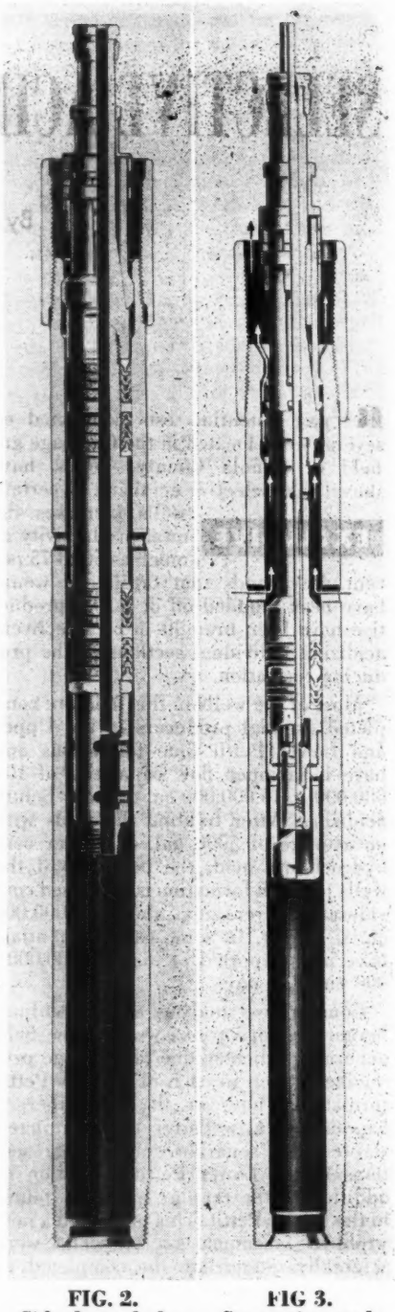

FIG. 2. Side-door choke. **FIG 3. Separation tool.**

This method of completing a well with dual packers and side-door chokes offers several distinct possibilities in fields where a multiplicity of pay zones exists. Instead of moving in a workover rig when one formation is depleted or to be changed for production demands, the side-door chokes or separation tool may be rearranged to produce the well from the desired section or sections. Also, this method could be utilized in wells in which the gas-oil ratio becomes too high. In such a case it would be possible to shut off the top section of the producing formation and produce only the lower section of the formation where a small gas-oil ratio may be known to exist.

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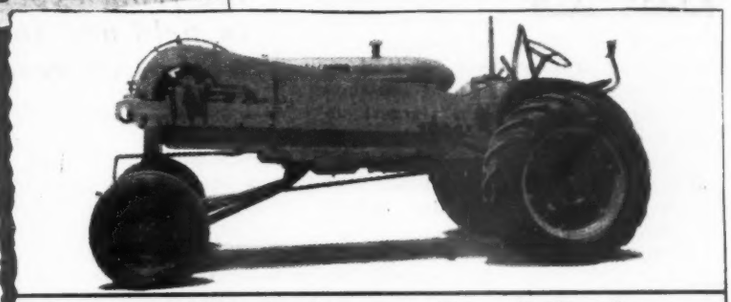

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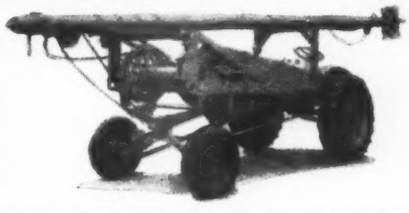

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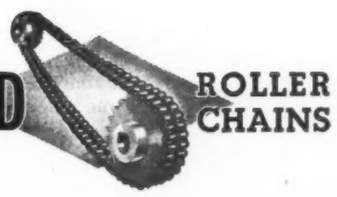


DIAMOND ROLLER CHAINS

INSTALLATION AND MAINTENANCE OF INTERNAL COMBUSTION ENGINE VALVES, SEATS, and GUIDES

By J. B. CREEK*

FOREWORD. The following data on industrial engine valve installation and maintenance should not be taken in its entirety as an authoritative scientific research to establish definite conclusions about the theories set forth, but simply as a summary of facts gathered through the practical experiences of 23 years of field and shop work for one of the world's largest engine valve manufacturers, and from the extensive research conducted by the sales and engineering departments of this company in their laboratory and on the engine test block.

EXCLUSIVE

To the writer's knowledge, no present day text book or operating manual presents to the operator of large industrial gas and diesel engines a comprehensive method of procedure on poppet valve installation and maintenance. The common practice has been to follow "rule of thumb" methods that have been handed down from journeyman to apprentice operator. It is hoped that this information may in some manner serve to establish standard procedure for installation and maintenance of valves, seats, and guides.

Inasmuch as valve timing, ignition timing and cooling are so interrelated with the life expectancy of valves, seats, and guides, it is believed necessary to touch on these subjects briefly.

In 1940 B. L. Rogers and O. H. Moore, superintendent and assistant superintendent of compressor stations, respectively, for the Lone Star Gas Company, presented a paper before the American Gas Association convention on "Four Point Control of the Four Cycle Gas Engine." The writer is indebted to Rogers and Moore for some of the material used on valve and ignition timing and wishes to express appreciation for their cooperation in making this material available.

● **Analysis of valve problems.** The valve mechanism of a 4-cycle internal-combustion engine has often been referred to as the heart of the engine. This is almost literally true, as valve leakage in an engine will shorten the life expectancy of the valve mechanism and, to a certain extent, the life span of the entire unit. Although the fuel injection valve mechanism in a 2-cycle engine does not affect operation to the same extent that inlet and exhaust valves do in the 4-cycle engine, it still has a very important bearing on engine efficiency.

Suggested procedures based on data resulting from experience in field and shop, as well as on research.

Assuming that the best available materials are being used in the valve mechanism, let us then analyze the problems that may be encountered in obtaining the ultimate in performance and life expectancy from the setup, and at the same time submit our recommended procedure on valve installation and servicing.

Any valve, as is known, is a mechanical device to seal off an opening that at times is under pressure. It goes without saying that the better the valve seals the more efficiently it operates, and the longer the life of both the valve face and the mating seating surface. This is particularly true on poppet type engine valves where compressed gases at high velocities with heat intensities of upward of 3000°F. may pass across a valve face that is not properly seated when combustion occurs. Of greatest importance, then, is the necessity for obtaining as nearly as possible perfect alignment between the valve, seat, and guide, so the valve and seat may perform their function of sealing without undue interference. We must consider the entire valve mechanism as made up of interrelated component parts, with relative preference shown the part exposed to the highest temperatures. Heat is the worst enemy of an internal-combustion engine valve.

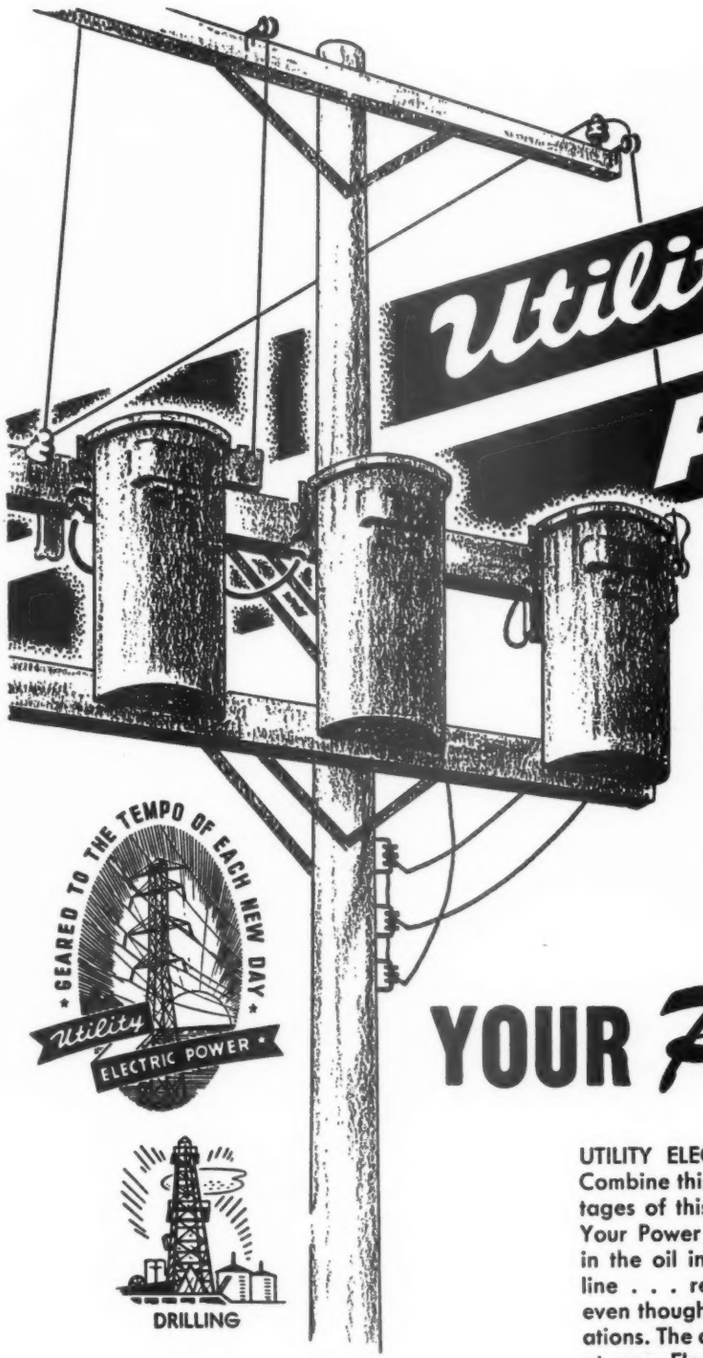
● **Clearance.** Assuming that a new valve as it comes from the manufacturer is straight and the face is concentric with the stem to within the required limits, little preparation is needed for its installation. If micrometer calipers are available, the valve stem and the inside bore of the guide should be measured to determine whether proper allowance has been made for running clearance. If micrometers are not available, it is possible to check the amount of clearance between valve stem and guide with a thickness gage. These running clearances are very important, as too little clearance will cause the valve to stick in the guide after it has attained operating temperature, and excessive clearance will cause a valve to "wallow out" the seat. Proper clearances vary with the type of engine, operating temperatures, etc., but a safe rule to follow on exhaust valves with alloy steel stems is to allow 0.001 in. for every ⅛ in. of stem diameter. In other words, a valve having a stem diameter of ⅞ in. should carry a mean of 0.007 in. clearance between the stem and guide. Valves with stems larger than 1½ in. diam. will generally operate with less clearance than provided by the above rule, due to the fact that valve cooling is better and operating speeds slower. Inlet valves should operate with clearances of approximately 0.001 in. for each 3/16 in. of stem diameter. Table 1 gives recommended clearances for valves of various stem diameters.

● **Valve servicing.** Valves that have been in operation for some time and are removed from the engine for servicing should be checked for wear on the stem, straightness of the stem, and, if necessary, should be refaced. Refacing operations may be performed in an engine lathe with a tool post grinder, or when available, in a valve refacing grinder. The least possible stock should be removed to obtain a suitable seating surface, as in operation the surface of the valve face work-hardens to a certain degree and removal of excess stock simply eliminates this very desirable condition. Some operators become unnecessarily alarmed over pitting on the valve faces of stainless steel valves. In diesel engines, or gas engines that burn considerable lubricating oil, this pitting condition may be expected and is due to small carbon particles impinging on the valve face. Unless it should happen that an interconnecting line of pits would form across the valve face, such action has no bearing on the valve's serviceability and

TABLE 1. Average clearance.

Valve stem dia., in.	Inlet, in.	Exhaust, in.
½	0.002 –0.004	0.003–0.005
⅝	0.0025–0.0045	0.004–0.006
¾	0.003 –0.005	0.005–0.007
⅞	0.004 –0.006	0.006–0.008
1	0.0045–0.0065	0.007–0.009
1⅛	0.005 –0.007	0.008–0.010
1¼	0.0055–0.0075	0.009–0.011
1⅜	0.006 –0.008	0.010–0.012
1½	0.007 –0.009	0.011–0.013
1⅝	0.0075–0.0095	0.012–0.014

*Mid-Continent division manager, Thompson Products, Inc. West Coast Plant.



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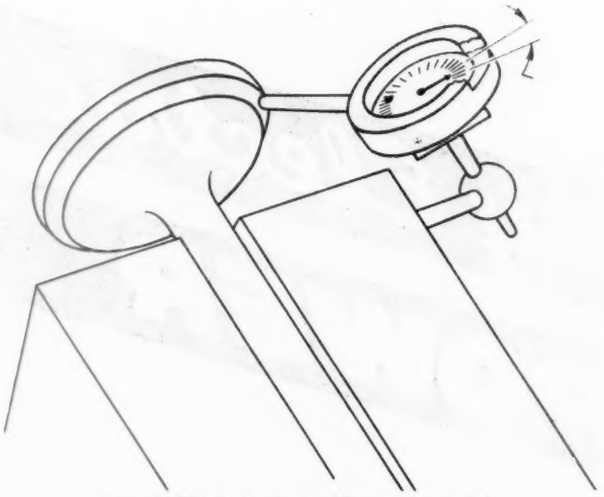

FIG. 1. Method of checking concentricity.

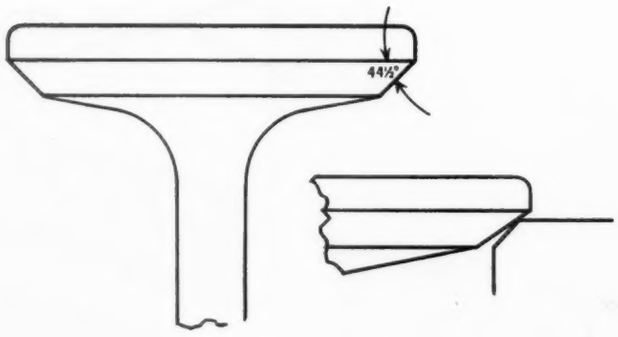

FIG. 2. Exaggerated view of facing operation.

should be ignored. In refacing such valves, it is not necessary to remove the pits from the face.

Concentricity of the valve face to the stem should be held within limits of a maximum of three-thousandths total run-out. The valve face angle should be re-ground to exactly match the seat face angle, unless guttering has occurred during the valve's operation in the engine. Guttering is a term used to describe the washing out of a trench across the valve face. When this condition occurs, it is advisable to face the valve at an angle ½ deg. flatter than the seat face angle. In other words, if the seat face angle is 45 deg., the valve should be faced to an angle of 44½ deg. This exerts greater pressure on the upper edge of the valve face and assures more certain sealing of the valve on the seat. (See Fig. 1.)

The accepted engineering practice is to have the valve face overlap the seat face on both the upper and lower edges. This method provides a more positive sealing arrangement and precludes the possibility of undue seat and guide wear when misalignment occurs between these parts. It also lessens the chance of the valve head doing a "reverse umbrella." Valve face and seat face widths vary, due to the peculiarities of design and operation of the valve mechanism. The writer favors a "middle of the road" policy on this subject. Inasmuch as about 90 per cent of the heat absorbed by the head of an exhaust valve must be transferred through the face during the short interval it rests on the seat, it is essential that the contact area be sufficient to effect properly this transfer. On the other hand, too great a contact area produces low unit pressure against the seat and may result in valve flutter. Inlet and fuel injection valves and seats should have relatively narrow faces, as no heat transfer problem is involved, and a narrow seat generally assures a more positive sealing surface. (See Fig. 2).

● **Valve seats.** It has become general practice in the last few years for engine manufacturers to equip their engines with removable exhaust valve seats. This has been accomplished in the seat-in-head, or seat-in-block, engines by means of a ring insert, usually held in place by installing it with an interference fit between the insert and the counterbore. In some instances threaded seats have been used, but in most cases without great success. This is due to the fact that, unless the threads are ground to a perfect mating fit on both the seat and in the counterbore, great loss of heat transfer occurs. Heat, like electricity, follows the path of least resistance, and air gaps between the seat and the wall of the counterbore will tend to inhibit its transfer. Experience has shown that it is almost impossible to install an insert with an interference fit and have it remain perfectly flat against the bottom of the counterbore. Consequently, it is estimated that approximately 90 per cent of the heat transfer from the seat to the cylinder head, or block, occurs through the sidewall of the insert. Therefore, we wish to stress the importance of obtaining the best possible contact between the outer wall of the seat insert and the radial wall of the counterbore. Most valve seat manufacturers provide their inserts with a smooth ground finish on the outside surfaces; however, due principally to lack of proper equipment, few engine manufacturers or operators have taken the pains to grind the counterbores in their cylinder heads or blocks.

There is now available to the industrial engine operator an excellent rotary type valve seat grinder that will grind counterbores of from 3¾ to 11 in. diam., as well as grind the seat angle on seats through this range of sizes.

On gas and diesel engines having removable valve cages, the general practice is to install a shoulder type valve seat, which replaces the nose end of the valve cage. Inasmuch as this type of seat is held in place in the cylinder head by the cage hold-down bolts, somewhat less painstaking care is required in the installation. In order to obtain maximum operating efficiency and service from the seat, however, a certain definite procedure should be followed in making the installation.

● **Valve seat installation.** First, let us outline our recommended method of installing seat inserts that are held in place by interference fit. Of great importance is the allowance for fit between the insert and counterbore. This is determined by the outside diameter and the radial (wall) thickness of the insert. Fig. 3 is a chart showing recommended allowances for alloy steel inserts. A properly designed seat insert with the radial thickness in proportion to the outside diameter requires a mean of 0.003 in. press fit. Due to the fact that most alloy steel seats have a slightly higher coefficient of expansion and greater elasticity than cast iron, it is not desirable to force them into the counterbores with a large interference fit. Once the counterbore size has been determined and bored or ground to size, the insert should be prepared for installation. It is recommended that, when the proper material is available, the inserts be shrunk before their installation in the counterbore. Dry ice is preferable for this purpose, but propane or butane is quite satisfactory. The parts may be sandwiched between thin slabs of dry ice and covered with paper and cloth, or may be immersed in a container of denatured alcohol or kerosine and dry ice. They should be kept in contact with the refrigerant until thoroughly cooled, requiring on an average about 30 min. If propane or butane is used, the seats should be placed in a shallow container and the liquid gas sprayed against them until they instantly become coated with frost when exposed to the atmosphere. Some operators prefer to heat the cylinder heads, as well as to freeze the seats. If this method is used, the head should be heated in boiling water. Never use a blow torch or acetylene torch, as this may cause distortion and a resultant cracking of the head. The counterbore should be cleaned and the seats taken from the refrigerant as needed and installed with an installation tool.

A very satisfactory permanent tool for installing one particular size seat may be made as follows: Use a round bar of steel that is at least ½ in. larger in diameter than the bore of the valve guide and long enough to extend well into the guide on one end and about 6 in. above the cylinder head, or block, on the other.

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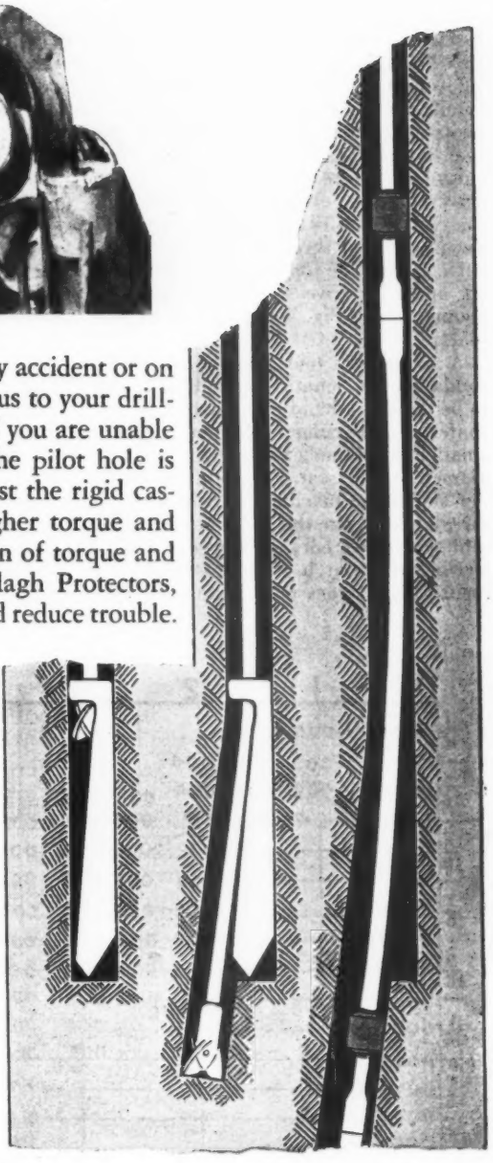
A DOGLEG is a potential source of trouble whether caused by accident or on purpose. In directional drilling it is a triple threat: dangerous to your drilling pipe, causes wear on casing and might defeat your entire project if you are unable to get the proper weight reading. When the whipstock is set and the pilot hole is angled off, it is only the flexibility of the drilling pipe working against the rigid casing that carries the torque around the bend. Without protectors, higher torque and greater friction result. With Patterson-Ballagh Protectors the reduction of torque and friction allows proper weight to be carried to the bit. Patterson-Ballagh Protectors, used as bearings above and below the dogleg, aid directional drilling and reduce trouble.



[redacted]OVES THIS POINT.

A well at Old Ocean, Texas, with a long string of 9⅝" casing set was having trouble with high torque, drilling at 11,025 feet. (350# steam against 7¾ x 7" engine). The pipe was fully protected, except for 16 protectors opposite the "dogleg." The torque reading was 85-100. These 16 Patterson-Ballagh Protectors were installed making the drill pipe 100% protected at every joint. The torque then dropped to 80-90 points. This is positive proof of the reduction of friction and the resulting tool joint and casing wear, which is the greatest cause of trouble in drilling an oil well.

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The entire length of the bar, with the exception of approximately 6 in., should be machined to a size that will slip fit into the bore of the valve guide, leaving a square shoulder on the 6-in. long unmachined portion. This 6-in. length will serve as a handle and driver. Now, machine a steel disk slightly smaller in diameter than the outside diameter of the seat insert and about ½ to 1 in. thick, depending on the size of the seat to be installed. Bore a hole in the center of the disk about 1/64 in. larger than the pilot part of the bar, and machine a shoulder on it to about 1/64 in. smaller in diameter than the inside bore of the seat insert. When the insert has been shrunk and is ready to be installed, the driver pilot should be inserted through the disk, which is then placed on top of the insert, and through the bore of the valve guide. The top portion is hammered upon to drive the insert into the counterbore. (Fig. 4 is a sketch of this tool).

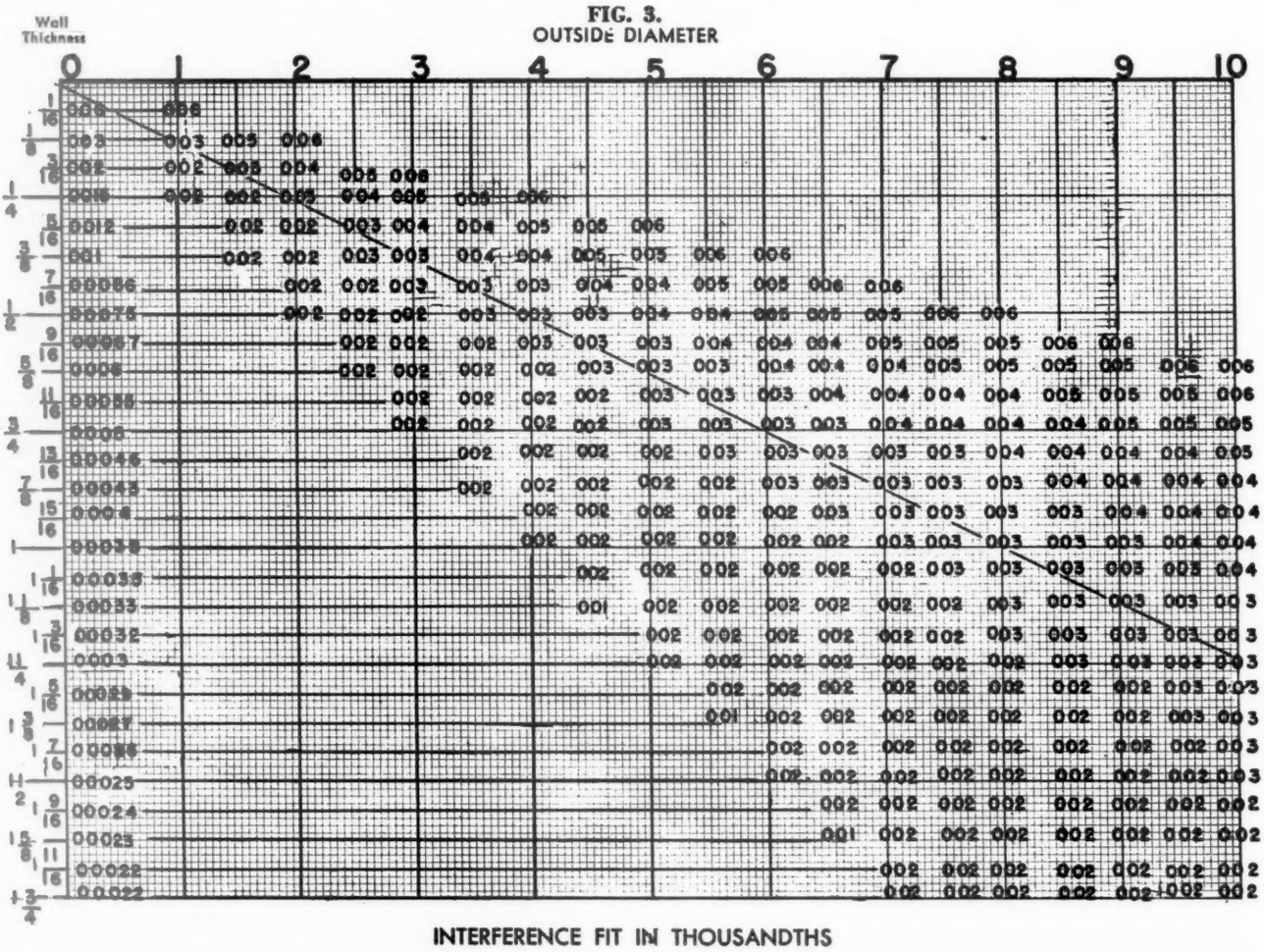
A temporary tool may be made by welding a 6-in. length of round bar stock, to be used as a handle and driver, to the center of a circular steel plate slightly smaller in diameter than the outside diameter of the seat. Preferably, a shoulder should be machined on the side of the plate opposite the handle to fit easily into the inside bore of the seat insert. Driving the seat in with this tool will assure that it goes in straight, and will eliminate the possibility of fracturing it, as sometimes happens when hammer blows are directed against the seat itself. After the insert has been driven into the bottom of the counterbore, it should be allowed to set until it returns to normal temperature. Then the cylinder head metal should be peened lightly against the chamfer on the upper outside edge of the insert. This will eliminate the possibility of the insert becoming wedged under the valve head, should it loosen in the counterbore due to a cracked cylinder head, distortion, or other causes.

● **Grinding valve seats.** The insert is now ready for the seat angle grinding operation, a very important step in the installation procedure. Seats having face diameters up to 3¾ in. may be ground with a concentric type automotive valve seat grinder, several makes of which are available. Seats above this size should be ground with a rotary grinder of the type previously referred to. Both types of grinders operate on the principle of revolving around a pilot inserted in the valve guide. In the former, the grinding wheel is carried on a ball bearing unit that revolves around the upper portion of the pilot, with the full periphery of the stone, which has been dressed to the desired angle, in contact with the seat. On the latter type grinder, the spindle carrying the grinding wheel is set off center to the pilot bearing, and the entire unit rotates around the pilot, with only a small poriton of the peripheral surface of the stone in contact with the seat. Both types of equipment are capable of grinding seat face angles to within 0.001 in. of concentricity between seat and guide. Dial test indicators are supplied with the above grinders for checking this concentricity.

After the seat angle has been ground true to the guide within the required limits, it should be checked against the valve to assure that the angle is correct and is matching the valve face in the proper proportions. This may be accomplished by smoothing a thin coating of Prussian Blue on the face of the valve and rotating it on the seat without pressure, or by lapping it in lightly with a very fine-grade water soluble valve grinding compound.

In regrinding seats that have been in operation for some time, it may be necessary to remove considerable stock in order to bring the seat face into concentricity with the guide, and in so doing the seat face will become wider than the valve face. Where this condition occurs it is advisable to narrow the seat face down by using a grinding wheel with an angle about 15 deg. flatter than the seat angle. In other words, if the seat angle is 45 deg. use a grinding wheel dressed to a 30 deg. angle. The upper seat face diameter should always be at least 1/16 in. less than the upper valve face diameter.

FIG. 3.



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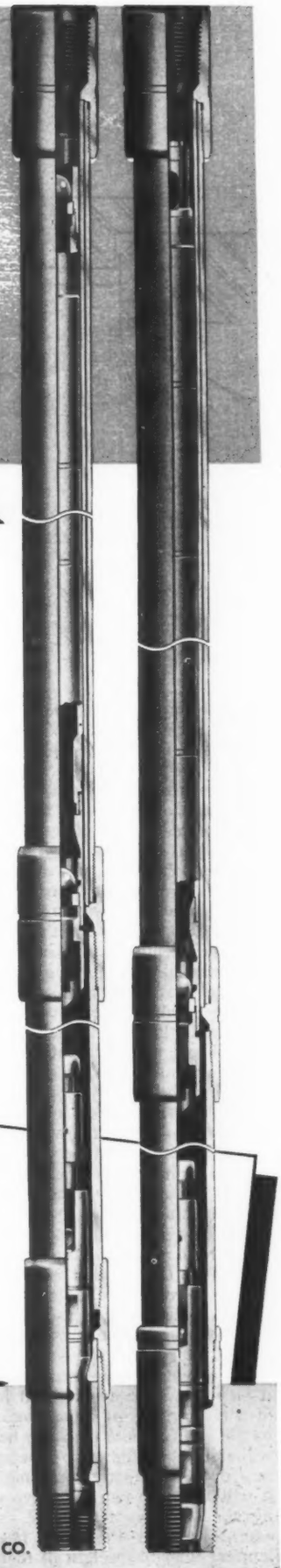

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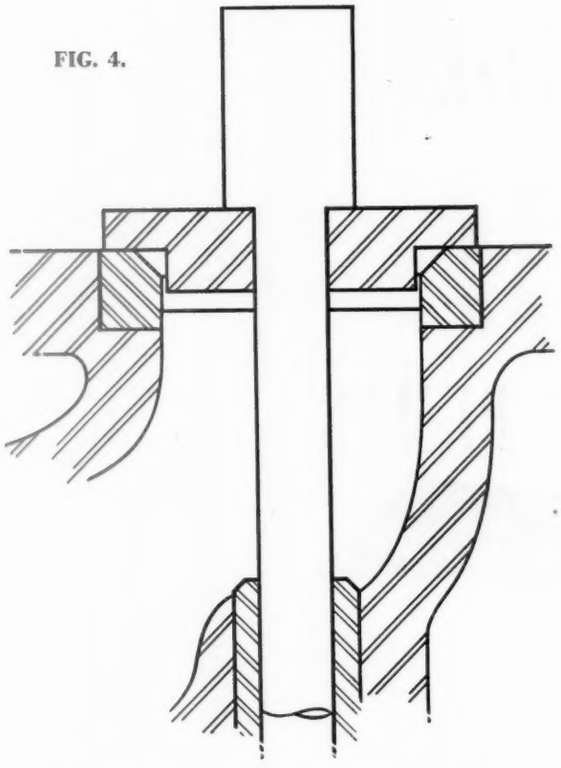
FIG. 4.



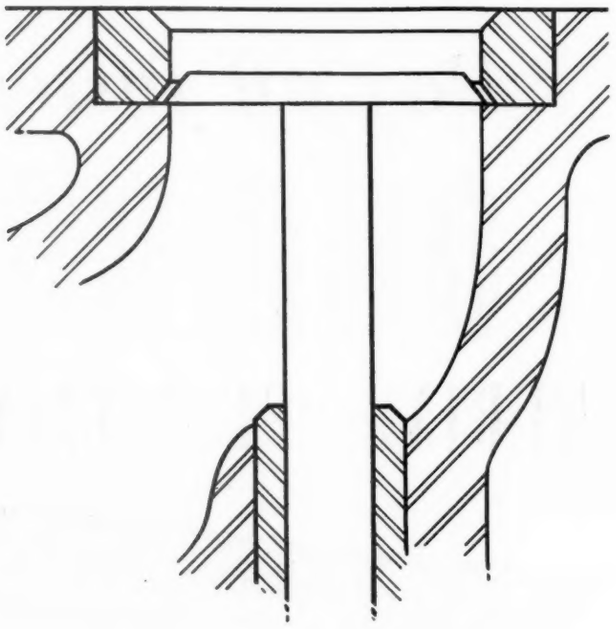


FIG. 5.

● **Valve grinding.** It has been the writer's experience that the less an alloy-steel valve is ground with grinding compound, the better it will function. High heat resisting steels have a much higher coefficient of expansion than low alloy steels or cast iron, and consequently will not seat in the same position when hot as when cold. Thus, we can see that if a ridge is ground into the valve or seat with compound, it will in all probability ride on that ridge when it attains normal operating temperature. Great care must be exercised when lapping in steel valves on steel seats with grinding compound, as steel rubbed against steel without lubrication between them has a tendency to gall and will cut small groves in the valve or seat face.

Before the introduction of the larger size valve seat grinder, it was frequently necessary to do considerable hand grinding with compound on the valve and seat to bring the seat in line with the guide. Consequently, many service men acquired the habit of driving the valve with a power tool and applying extreme pressure to make the abrasive compound cut faster. If any other means of grinding in valves is available, this practice should be discouraged, as it brings about the very undesirable conditions mentioned. If the valve must be lapped in with compound, it is recommended that it be rotated against the seat by means of a tap wrench or lathe dog, fastened on the end opposite the valve head. This will assure that the valve is being lapped into place in exactly the same position it will assume when the valve spring is installed. No more pressure should be exerted against the valve head when lapping than the weight of the valve itself. The abrasive compound should be changed frequently and the old compound removed from the valve and seat before new is applied.

The procedure outlined for installing press-in seat inserts may also be used to good advantage on cage type seats, although it is not essential that the seats be shrunk before installation of the cage. This is due to the fact that they are not held in place by interference fit, and there is no peening necessary where the seat extends into the cylinder head. On engines having valves in removable cages, it may be found preferable to grind the seats after installing the cage in the cylinder head. This method eliminates inaccuracies caused by distortion that may occur between the seat and guide due to the cage hold down bolts being unevenly adjusted.

● **Seat insert removal.** Considerable difficulty has been experienced by many operators in removing the press-in type of seat inserts. Although no cure for all such difficulties can be offered, the following is a method that is very effective in removing inserts that have a relief or bevel on the lower inside edge. This method requires a piece of hardened square steel of the proper size, cut off to a length just slightly above that of the inside of the insert, as shown in Fig. 5. This piece is beveled off on each end approximately 45 deg. to almost a sharp edge. It is inserted under the seat at the chamfer, or relief, and a round bar that will go through the valve guide hole is placed against the tool and hammered on to knock the seat out. In removing the seat with this tool, it should be rotated slightly after each blow to prevent any chance of cocking or tipping the seat in the counterbore. One company has available a special adjustable valve seat removing tool. This tool operates on the toggle joint principle and will readily force out seats that have a chamfer on the lower inside edge. A reversible gear puller may also be used on the above type seat.

● **Valve guides—installation.** Next of importance to the valve and seat in the mechanism of an engine is the guide. Perhaps too little significance has been attached to the role this part plays. Proper clearance between guide and valve stem, and alignment with the valve seat, have already been stressed, therefore installation will be dealt with briefly. First, the guide bore in the cylinder head, block, or cage should be checked to ascertain whether it has become worn. The fit diameter of the guide should then be measured to determine whether it has the proper interference fit in the bore, A safe rule to follow here is to allow 0.001 in. fit for each inch of fit diameter of the guide. For example, a guide having a fit diameter of 2 in. should have 0.002 in. press fit. It is very important that guides not be installed with too great an allowance for press fit, as there is danger of breaking the guide, or of distorting the bore in the guide itself, which may cause the valve to stick.

It is desirable to have the guide extend well up toward the valve head, but it is most important that a thin wall section is not allowed to extend unprotected into the open exhaust flame. If so, the thin section will tend to curl as the exhaust flame sweeps across it, and will cause valve sticking and leakage. A good investment in engine operating efficiency is to replace worn guides or bushings at regular intervals. They should never be operated with clearances of more than twice that originally allowed new parts.

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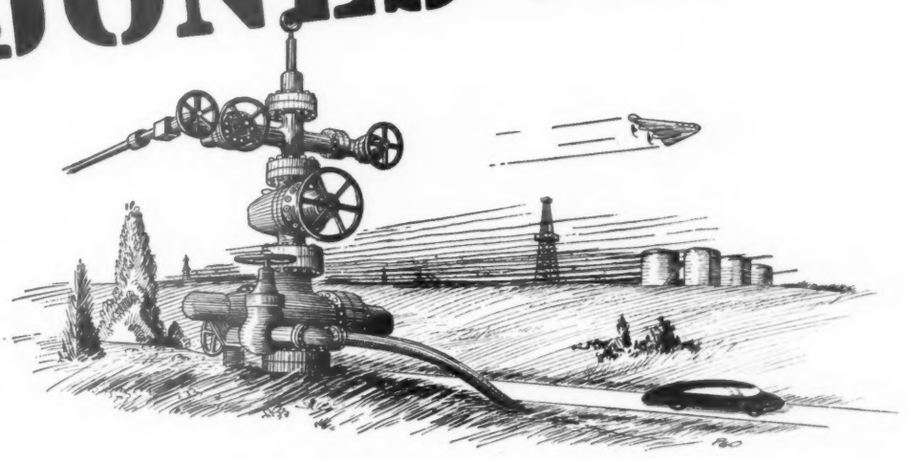

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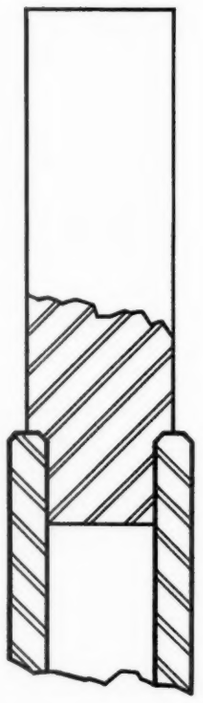
● **Maintenance.** Some cage type engines do not have removable valve guides. In most cases, however, it is no great problem to bore these out to accommodate bushings having a wall thickness of from ⅛ to ¼ in. In the boring operation it is important that the cage be bored out to size for its full length and from the same end. On unusually long cages it is desirable to install two bushings with a total length somewhat less than the length of the cage. A bushing should be pressed in each end, leaving a space between the two in the center of the cage for an oil pocket. This method also lessens the chance of the valve sticking in the guide due to cage distortion. Preferably, guides and bushings should be pressed in or out by means of a hydraulic or screw press. If neither of these is available, it might be necessary to drive them in or out. This may be done by using a driving tool made from a round steel bar slightly smaller than the outside diameter of the guide or bushing. A portion of the bar, say ½ to 1 in., is machined to a diameter slightly under the size of the hole in the guide. The shoulder should be slightly undercut so that it will ride on the outer edge of the guide. It is then inserted in the guide hold and used to drive the parts into place. (See Fig 6 at right.)

FIG. 6.



● **Lubrication.** The writer has had many inquiries regarding valve guide lubrication, but regrets that, to his knowledge, there is no lubricant available that can be recommended as entirely suitable for this application. Probably the most effective, and least injurious, is a 50 per cent kerosine and 50 per cent upper cylinder oil solution. Where lubrication connections direct to the guides are provided, it is possible to install Zerk connections and apply a chassis lubricant by means of a grease gun. Some operators have found such lubricants quite effective. It has been the writer's experience that under-lubrication of valve stems is more desirable than over-lubrication, as valve stem and guide wear are preferable to a burned valve that may result from a gummed, sticking stem. To partially alleviate the problem of lubrication, or wear, one valve manufacturer supplies heat-treated nickel iron guides with a ground or honed finish in the bore. These, together with their heat-treated stem valves, will run for unusually long periods with little or no lubrication.

● **Valve springs.** Since the introduction of the Stroboscope, considerable advancement has been made in the study of valve spring action of the internal-combustion engine, and the development of higher quality springs for this particular application has resulted. As in the case of alloy steel valves and seats, however, the larger industrial engine manufacturers and operators have lagged behind the automobile and aircraft engine manufacturers in taking advantage of the new developments. This is no doubt due to the fact that if spring weakness develops in the slower speed industrial engine, the consequences are not so obvious as in the higher speed engines.

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ble in the slow speed industrial engine is breakage and hammering out of the valve seat, the latter caused in most cases by a spring that is too weak. Each case of spring breakage must be treated individually and an analysis made of all factors that might contribute to the failure. It has been observed that often spring breakage occurs when an engine is operated at a fixed speed, such as on generator drives. This is particularly true where two springs per valve are used. In many cases, this may be due to a vibration harmonic set up in the spring, which eventually causes fatigue failure. Considerable experimentation may be necessary to eliminate such harmonics. A stronger spring, one having a greater, or lesser, number of coils, or one having a certain number of coils part way and a lesser number on the remaining portion of the spring, may solve the problem. When two springs are used per valve, it is very important that the lead winding of the inner and outer springs go in different directions. In other words, if the inner spring is a left-hand wind, the outer spring should be a right-hand wind. Inasmuch as air starter valve springs give considerable trouble from corrosion, caused by condensation, it is advisable to have these springs made from a stainless steel wire. Contrary to a widespread opinion among industrial engine operators, hammering out of the valve seat is often caused by a valve spring that is too weak, not by one that is too strong. This statement of course holds true only on cam-operated valves, and is made under the assumption that rocker arm or tappet clearances used are those specified by the engine manufacturer. Obviously, on cam-operated valves the travel of the valve will exactly follow the contour of the cam, if the valve spring is sufficiently strong, and it will strike the seat with only the force developed in the space provided for rocker arm or tappet clearance. Thus we can see how vitally important it is to maintain the proper clearance between the rocker arm or tappet and the end of the valve stem. On the other hand, if a sticky valve is operated with a weak spring, the cam may leave the valve, and when it finally closes, will strike the seat with considerable impact. Valve springs should be checked for compression pressures at the time of each valve servicing, and in between these periods if there are indications of spring weakness. Lacking access to a regular spring tester, a comparison test may be conducted as follows: Use a small platform weighing scale, set up under a drill press or a lever hinged at one end as shown in Fig. 7.

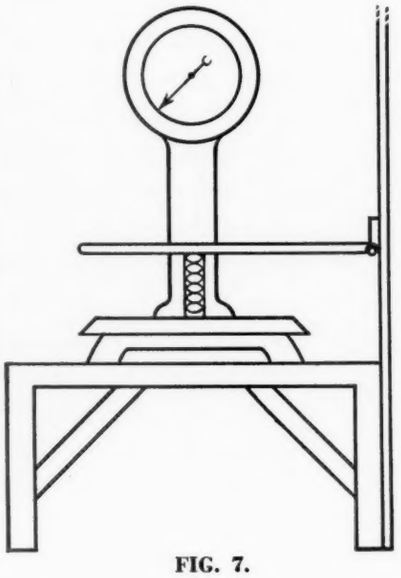

FIG. 7.

Using a new factory equipment spring, compress it on the scale to operating length with the valve completely open, by means of the drill press or lever arrangement. Make a note of the pounds reading on the scales. Now, use the same procedure on the used springs to be tested, and you will have an accurate comparison. Springs that show more than 10 per cent variation under the compression pressure of a new spring should be replaced.

● **Exhaust valve timing.** Exhaust valve timing in the 4-cycle engine has a very important bearing on both operating efficiency and life expectancy of valve parts. Proof of the efficiency factor is brought out by citing an example of automotive engineering. In 1939, the De Soto automobile engine was rated at 93

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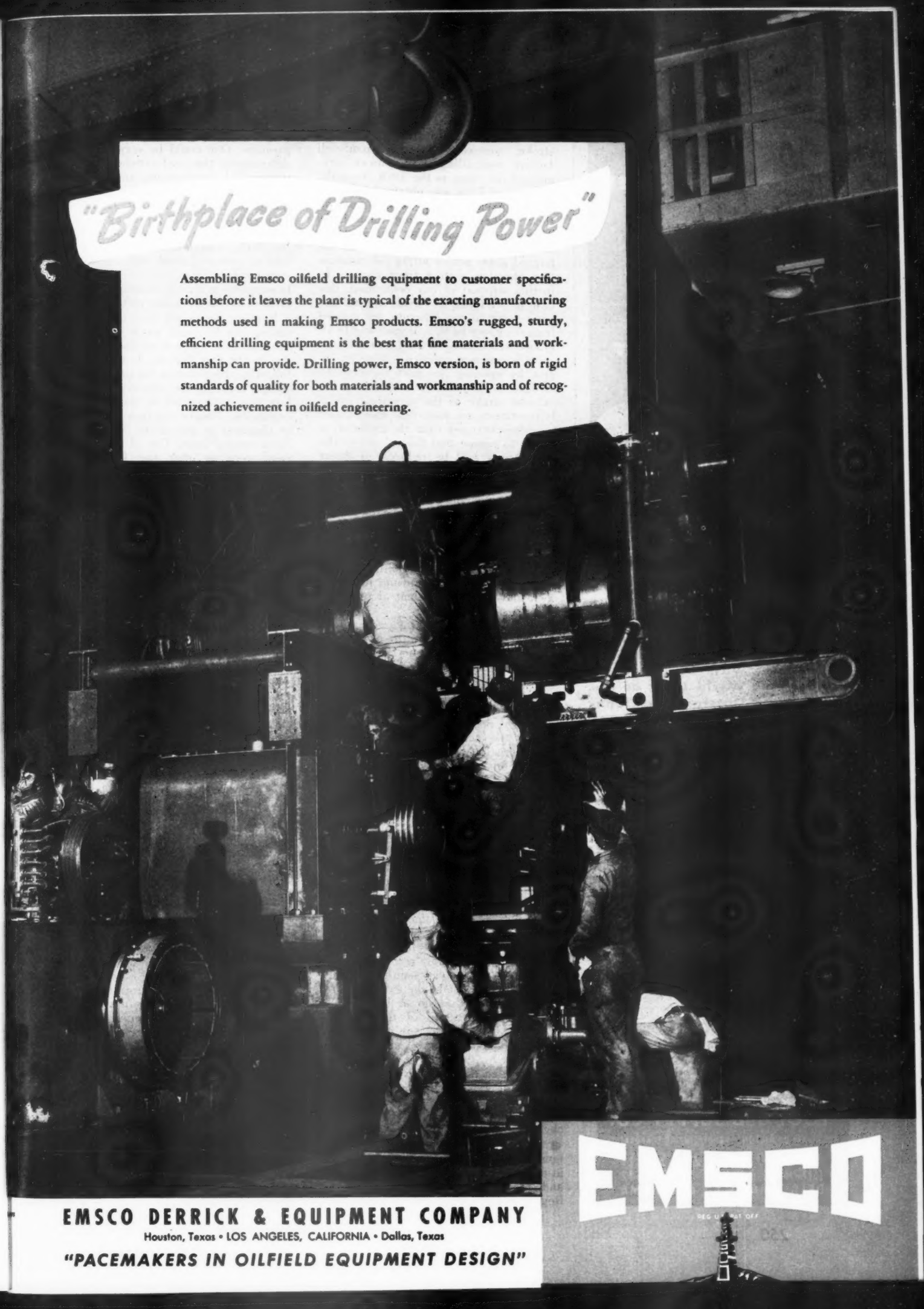
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b. hp. The engine in the 1940 model was rated 100 b. hp., although the bore and stroke, compression ratio, r.p.m.—all factors controlling horsepower — remained the same as the 1939. Actually, the gain of 7 hp. was obtained by opening the exhaust valves earlier, opening them higher, and closing them later. This step-up in operating efficiency was obtained simply by clearing out all the burned gases before filling the combustion chamber with a fresh charge. In further support of our contention, this time in reference to 4-cycle natural gas engine operation, excerpts are quoted from the paper by B. L. Rogers and O. H. Moore, referred to in the foreword:

"It is common practice to time an engine by opening the inlet valve ahead of dead center, without considering the exhaust stroke of the preceding cycle. If conditions are such that spent gases are not scavenged from the cylinder, it stands to reason that the volume of the new charge will be reduced in direct proportion to the quantity of spent gases trapped in the cylinder. Incomplete scavenging of a cylinder has a very detrimental effect on the running of an engine because:

"First: The spent gases must be expanded to below atmosphere before any of the new charge is admitted to the cylinder. This uses up piston displacement and is the equivalent of reducing cylinder dimensions.

"Second: These spent gases are hot and increase the temperature of the new charge as it is drawn into the cylinder, thereby reducing the net volume of the mixture that can be drawn into the cylinder.

"Third: They do not assist in the combustion of the new charge, but actually change the compression and burning characteristics of the mixture. In the past our operators timed an engine from the inlet valve (setting the opening point according to valve clearances on the cold engine) and then expected it to operate efficiently. All these careful adjustments may have been for naught, for we have found inlet valves opening as much as 18° later after the engine came up to running temperature.

"When an engine is adjusted by the use of instruments, the operating characteristics are shown under actual running conditions. This means that any wear affecting the operation of the unit will show up in the data recorded by the instruments. As wear manifests itself to a greater extent in the exhaust than in the inlet mechanism of the 4-cycle engine, the operation of the exhaust valve is often thrown out of synchronism with the piston travel when engines are timed by the inlet valve only. We have adopted the practice, therefore, of timing our 4-cycle engines by exhaust valve, using the exhaust curve of the light spring indicator diagram as our checking medium."

● **Ignition timing.** Ignition timing must also be given due consideration in order to obtain the maximum service and life from valve parts. To quote Rogers and Moore: "The ignition point of the fuel charge ties very closely into proper valve setting and compression pressure. One could be very careful in determining the most satisfactory valve timing and compression, and have this work offset if the charge were not ignited at the proper point. Early ignition results in loss of power by bringing about maximum pressure too early in the cycle. Too late ignition results in loss of power through maximum pressure not being reached sufficiently early to overcome a rapidly increasing volume created by the receding piston."

It might be added that late ignition timing can be much more injurious to exhaust valve parts than early ignition, due to the fact that the burning gases, following the piston on the power stroke, escape through the exhaust valves before they have cooled by the process of expansion. Proper ignition timing can be obtained by use of the Stroboscopic Neon timing light. Use of this instrument requires that the flywheel be marked for exact top, or outer, dead center, and for the specified firing position of a designated cylinder. Dead center may be arrived at by using a dial indicator on top of the piston, or, less preferable, a spirit level on the crankshaft. This position should be permanently marked on the flywheel, and a pointer extending from the engine frame set up at this point. The firing point on the flywheel may be found by measuring the circumference of the fly-wheel with a tape measure and dividing the total number of inches by 360°. This gives the number of inches per degree, or vice versa. If it figures 1° per in., and ignition should occur at 20° before top dead center—the firing point on the fly-wheel should be marked 20 in. before dead center—in the direction in which the flywheel rotates. This point should then be marked across the flywheel with a thin stripe of white paint. Now hook the Neon timing light in series with the spark plug on the cylinder to be tested, and with the engine operating at normal load let the flashes from the timing lamp show up the white ignition point stripe on the flywheel. If this white stripe shows up at the exact position of the pointer, ignition is correct. If not, the proper adjustment should be made.

● **Water cooling.** The need for proper water cooling of an internal-combustion engine to obtain longer valve life should not be overlooked. Installations having closed systems and treated water usually offer few problems along this line. Where such equipment is not in use, however, great caution should be exercised to see that cylinder head water jackets and passages are kept open and free from scale. This is particularly true on engines relying on gravity flow of their jacket water where no turbulence is created to carry away the scale formations. It can readily be seen how the plugging up of a water passage in one side of a cylinder head would create a hot spot in that area, causing distortion of the cylinder head with the possible consequences of a leaky valve or loosened seat insert. ★★★

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NEW PIPE LINE OUTLET FOR CARTHAGE

By **FRANK H. LOVE,** *Managing Editor*

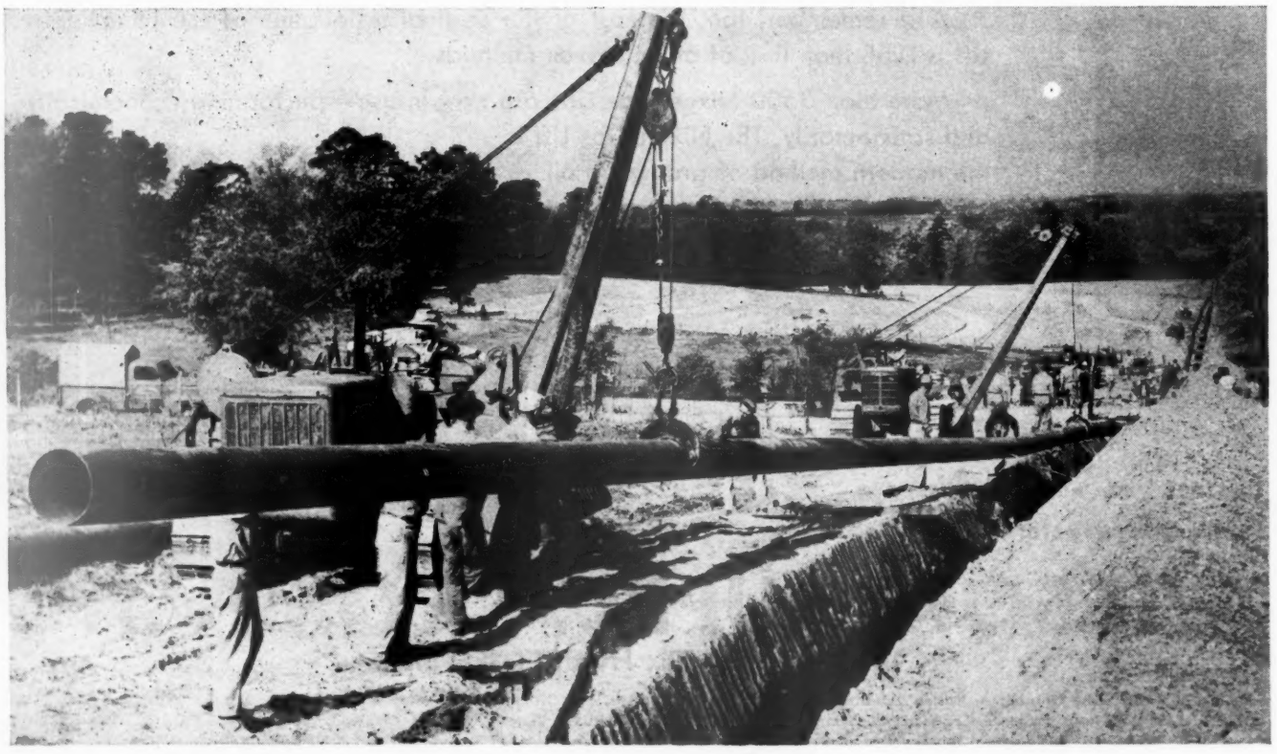
THE Lone Star Gas Company has completed the laying of a 14-in. transmission system from Carthage to Opelika, Texas, which when placed in operation will give the large Carthage gas field an additional pipe line outlet. Operation of the line awaits completion of the field gathering system and a cycling plant now being erected at at Carthage by Lone Star Producing Company. At Opelika, a distance of 79.5 miles, the new line will be tied into Lone Star's main transmission system.

EXCLUSIVE

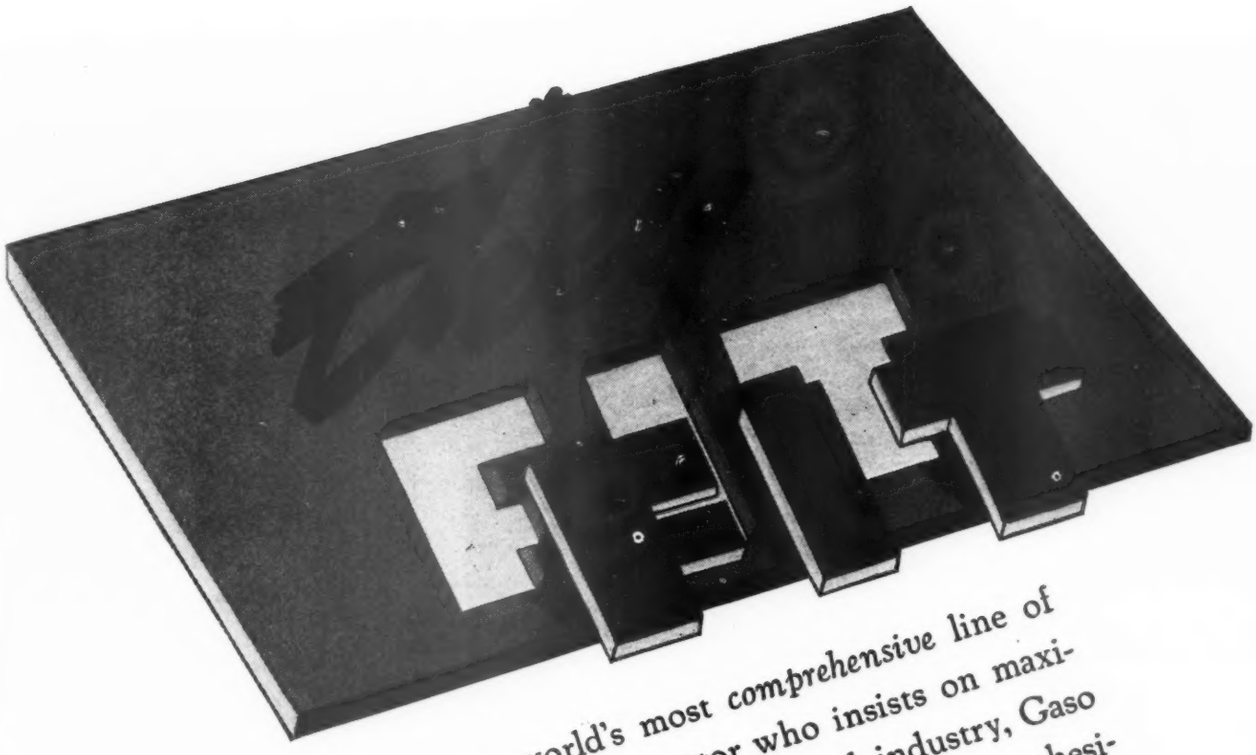
Inasmuch as wellhead pressures are extremely high in the Carthage field (2500-3000 lb. per sq. in.), it will be necessary to reduce the pressure before the gas enters the line, which is designed for operation at 1200 lb. Reduction of pressure will be accomplished by pressure regulators in the case of certain dry gas wells that will bypass the cycling plant and discharge directly into the line. In the case of gas-condensate wells, a part of this gas, after being processed, will be returned to the producing formations to maintain pressure, and a part will be discharged from the plant into the line. In the latter instance, reduction in pressure will be effected at the plant.

The design capacity of the new line

Cleaning and priming the pipe before applying coating.



Lining-up and joining the line by the stove-pipe method.



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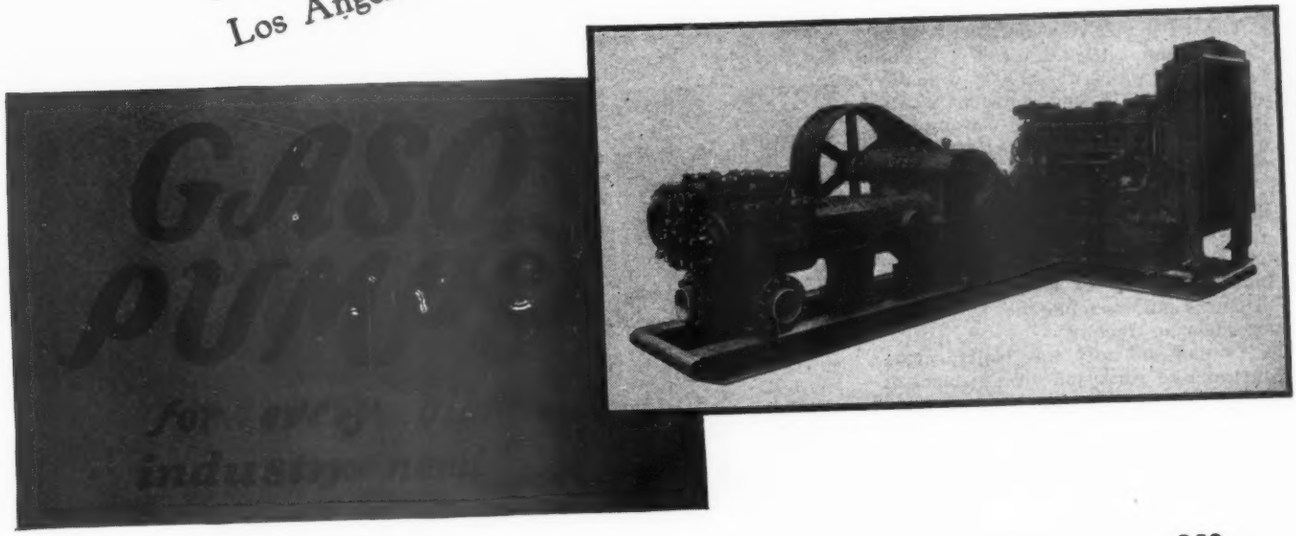

ALL PHOTOS BY THOMAS K. CONE EXCEPT TWO AT LEFT, WHICH ARE BY OKLAHOMA CONTRACTING CO.

Above—Carrying in poles to right-of-way to make a road.

Right—The rip-rapped road finished; pipe laid alongside.

Above—Making a weld by the electric-arc method; three beads run.

Below—Making ditch with trench hoes in area unsuitable to machines.

is 100,000,000 cu. ft. a day at 1200-lb. pressure, and, incidentally, this is the first transmission system installed by Lone Star Gas Company to operate at a pressure above 500 lb.

● **Line construction.** Although this could have been "just another pipe line job," Nature decided to take it out of that category and by providing rain in copious quantities during the three-month period while construction was in progress, made the job, according to veteran pipeliners intimately concerned, one of the toughest of their experience. From the time work began about January 1 until completion some three months later, it is estimated that rain fell daily except for a possible total of 14 to 21 days. Such conditions made necessary the construction of numerous log roads over which the heavy equipment could move, resulted in caving ditch on many occasions, and generally contributed to the slowing down of the work. Some of these roads contained as many as six layers of logs, and some strips were as long as 8000 ft.

Two particularly swampy areas were the Big and Little Martin Creek Bottoms, one of which was 4500 ft. wide, the other 3000 ft. In such locations it was impossible to employ the conventional ditching machines and trench hoes were used.

Construction of these roads, always time-consumers on a pipe line job, frequently was made difficult due to the unavailability of logs, which had to be brought in by truck from considerable distances and taken into the right-of-way by sideboom tractors.

Another difficulty was badly caving ditch due to quicksand for a distance of about 25 miles between Carthage field and Kilgore.

Still another problem was the fact that the line runs through the East Texas oil field with its maze of intercrossing flow

Through good terrain the trench was cut with ditching machines.

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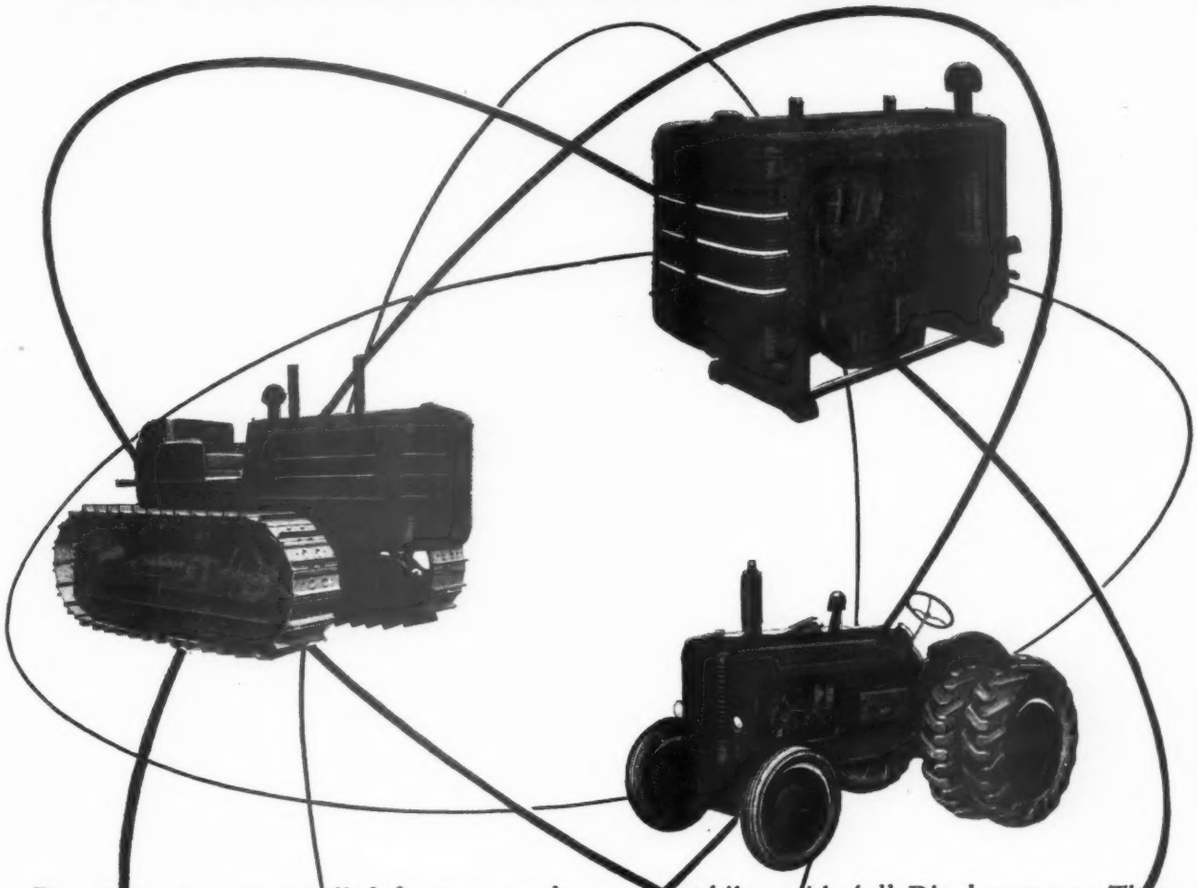

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Above—Lowering the pipe into ditch after it has been coated and wrapped.

Below—Applying coating and wrapper with traveling-type machine.

lines, gathering lines, and transmission lines. It was necessary to go under approximately 256 pipe lines of various types. This phase of the work called for systematic procedure. First, the man in charge of the lease to be crossed was contacted. Usually lease maps showed the location of all lines, although in some instances these were not always complete. The lines were located and flagged, after which they were uncovered by hand. With the lines thus exposed, the ditch was made with backhoes or ditching machines, as conditions permitted.

Two spreads were used by the contractor, working from both ends of the line. One had its headquarters in Henderson and the other in Tyler. Welding was by the electric-arc method with three beads being run. Each spread employed 12 welders. Before being hired for the job each welder was required to pass a test specified by Lone Star.

Electric welded pipe in 40-ft. lengths was used to lay the line, all of which was new. The pipe has a yield strength of 45,000 lb., weighs 38.15 lb. per linear ft., and has a wall thickness of 0.260 in.

Only one river was crossed, the Neches. Normally the width of this crossing, which was made near Chandler, on the Opelika end of the line, would be only about 100 ft., but because of the heavy rains the river was out of its banks and about 4000 ft. wide. Consequently, the construction crews moved around and came back and laid the crossing at a later date when conditions were more favorable. No river clamps were used on the crossing, instead a trench was cut through the river bottom and the pipe buried.

Other than for the exceptions noted herein, the line was laid in a conventional manner. Throughout its entire length the pipe was given a hot enamel coating to a minimum thickness of 3/32 in., and was wrapped with Kraft paper and asbestos felt.

● **Contractor.** The contractor in charge of the work was the Oklahoma Contracting Company of Dallas, Texas. ★★★

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(1) *Otis tubing caliper*

Otis Pressure Control, Inc., through an arrangement with the Sun Oil Company has been granted exclusive license to provide a corrosion survey service for internal inspection of well tubing by use of a new instrument to be called the Otis Tubing Caliper.

This instrument, known during its development as the Chaney-Barnes Tubing Caliper and the Sun Oil Company Tubing Caliper, was designed by P. E. Chaney, and W. E. Barnes, petroleum engineers, Sun Oil Company production department.

The Otis Tubing Caliper has already been successfully used in high pressure wells. It detects and records both the extent and location of corrosion in tubing and accurately measures the depth of pits. Tubing surveyed by the caliper has been pulled, cut open, and visually inspected, and in each instance Otis Tubing Caliper readings were proved correct, it is stated.

Calipering is accomplished by six or eight independently operating lever arms, each with a small wheel attached to the outer extremity to contact the tubing wall. Each lever arm is pressed against the tubing wall by means of a spring, and connects with a stylus that in turn is impressed against a metal foil chart. The impression made on the chart by the stylus is controlled by movement of the lever arms. When the wheels reach a pitted area in the tubing wall and depress into the cavity, the stylus is proportionately affected and records a comparable line on the chart.

Tubing unaffected by pitting or other corrosion will be indicated by a comparatively straight line across the chart. Tubing with pitted areas will be shown on the chart by erratic lines having peaks in proportion to the depth and extent of the pitted area. The Otis Tubing Caliper indicates minimum wall thickness at any point traversed rather than the average thickness at that point. This is a distinct advantage, for the safety of the tubing in relation to pressure is determined by minimum wall thickness.

The Otis Tubing Caliper is run under pressure on a steel measuring line. There are no packing glands, and full well pressures are admitted to all parts of the Caliper. The chart is treated with a special oil and water resistant coating to permit logging in the presence of oil well fluids.

Otis service crews, consisting of an engineer, and a wire line specialist experienced in installing and maintaining sub-surface controls under pressure, will run the Otis Tubing Caliper to inspect tubing in areas where corrosion is either in evidence or suspected to be prevalent.

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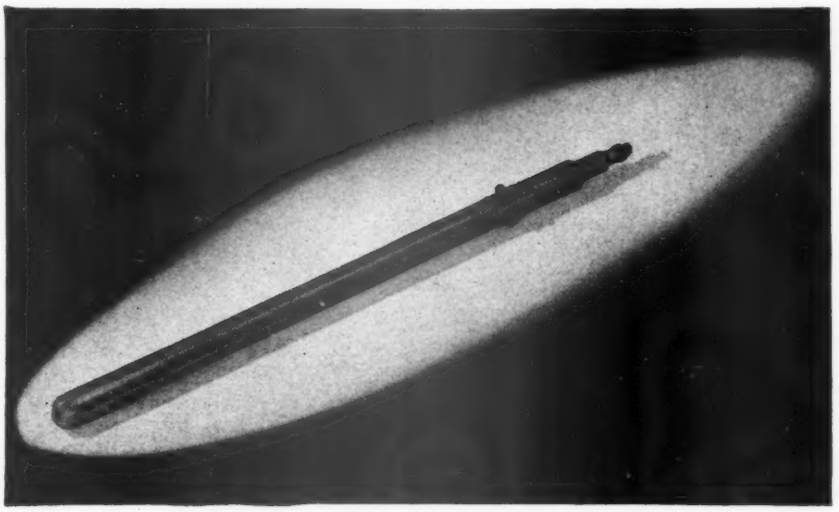
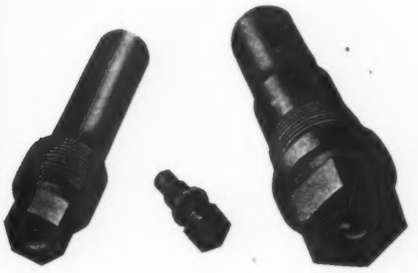


(2) *Unibolt flow beans*

To control more accurately the flow of oil or gas through positive checks, Thornhill-Craver Company, Inc., Houston, Texas, has introduced its Unibolt "X" type flow bean, which is an innovation in that it is gauged in increments of 10 per cent of flow rather than fractional 1/64 in. sizes. Unibolt "X" type beans are available in 60 sizes up to ½ in. and 31 sizes up to ⅛ in., as compared with only 16 sizes of fractionally drilled beans up to ⅛ in.



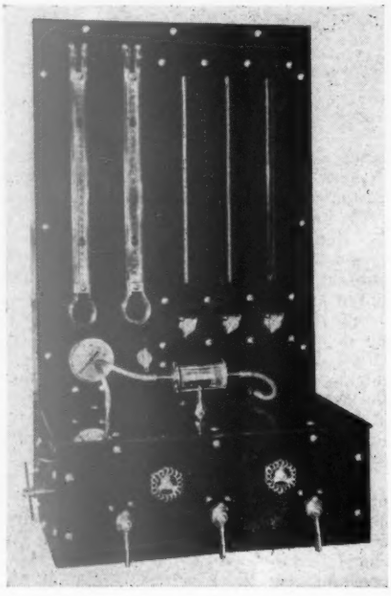
(3) *Relative permeability*

Core Laboratories, Inc., Dallas, Texas, announces the completion of a new apparatus for the measurement of relative permeability to gas.

Relative permeability to gas is defined as the ratio of the effective permeability to gas at a given percentage saturation of gas in the pores, to the specific permeability of the porous medium at 100 per cent gas saturation.

The apparatus measures the relative permeability to gas at a number of saturations covering the range normally existing in reservoirs during pressure decline.

Core Laboratories, Inc., plans to make relative permeability to gas measurements on oil-productive formations that are core analyzed on location, and to use these data in



presenting estimates of pressure decline and gas-oil ratio versus oil recovery.

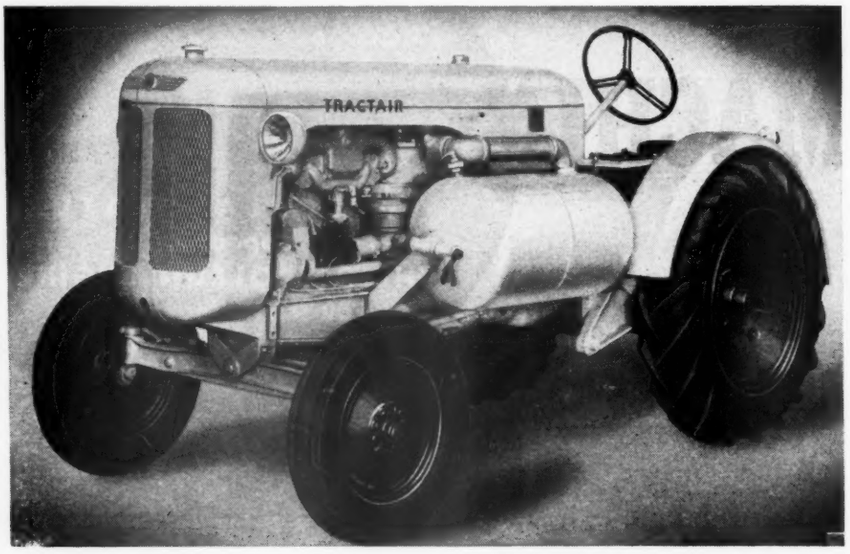
Relative permeability characteristics may show considerable variation among different reservoirs. This is important because the ratio of relative permeability of gas to that of oil governs the rate of increase of the produced gas-oil ratio and hence the rate of decline of reservoir pressure and the ultimate recovery obtainable. Variations in gas relative permeability alone, with all other conditions equal, may cause as much as a two-fold variation in ultimate recoveries.

This particular relative permeability apparatus is a product of Core Laboratories, Inc., research department, and was assembled by John D. Wisenbaker and Henry Lewelling under the direction of Dr. Frank C. Kelton.

(4) *Tractor compressor*

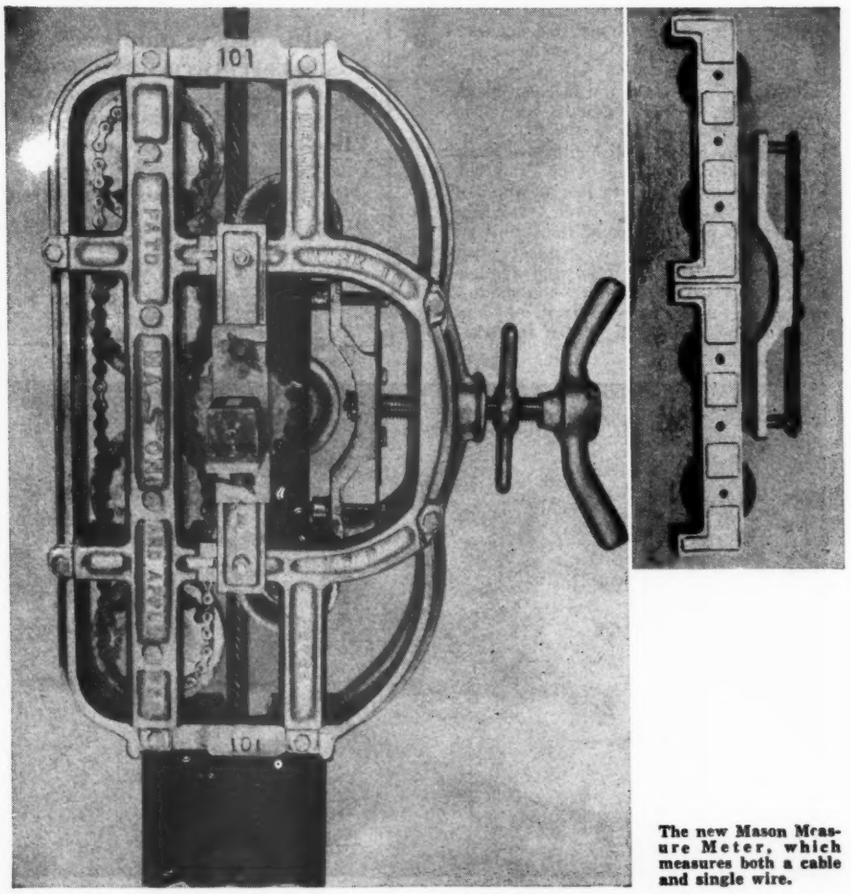
Le Roi Company, Milwaukee, Wisconsin, and Greenwich, Ohio, manufacturers of industrial engines, air compressors, highway-airport-railway mowers, and engine generator sets, have developed a unique combination tractor-compressor unit known as Tractair.

This entirely new and exclusive development incorporates an integrally built 105 c.f.m. compressor with a 35-hp. wheel tractor, retaining complete and dual utility of both units and resulting in exceptional mobility over all types of terrain. Surveys indicate that this new product will have unusual demand in the oil producing fields by bringing both pneumatic and mechanical power to applications heretofore inaccessible, the manufacturer states. A full complement of front and rear mounted power equipment is available and in process of development to add further to the multi-purpose utility of this machine.

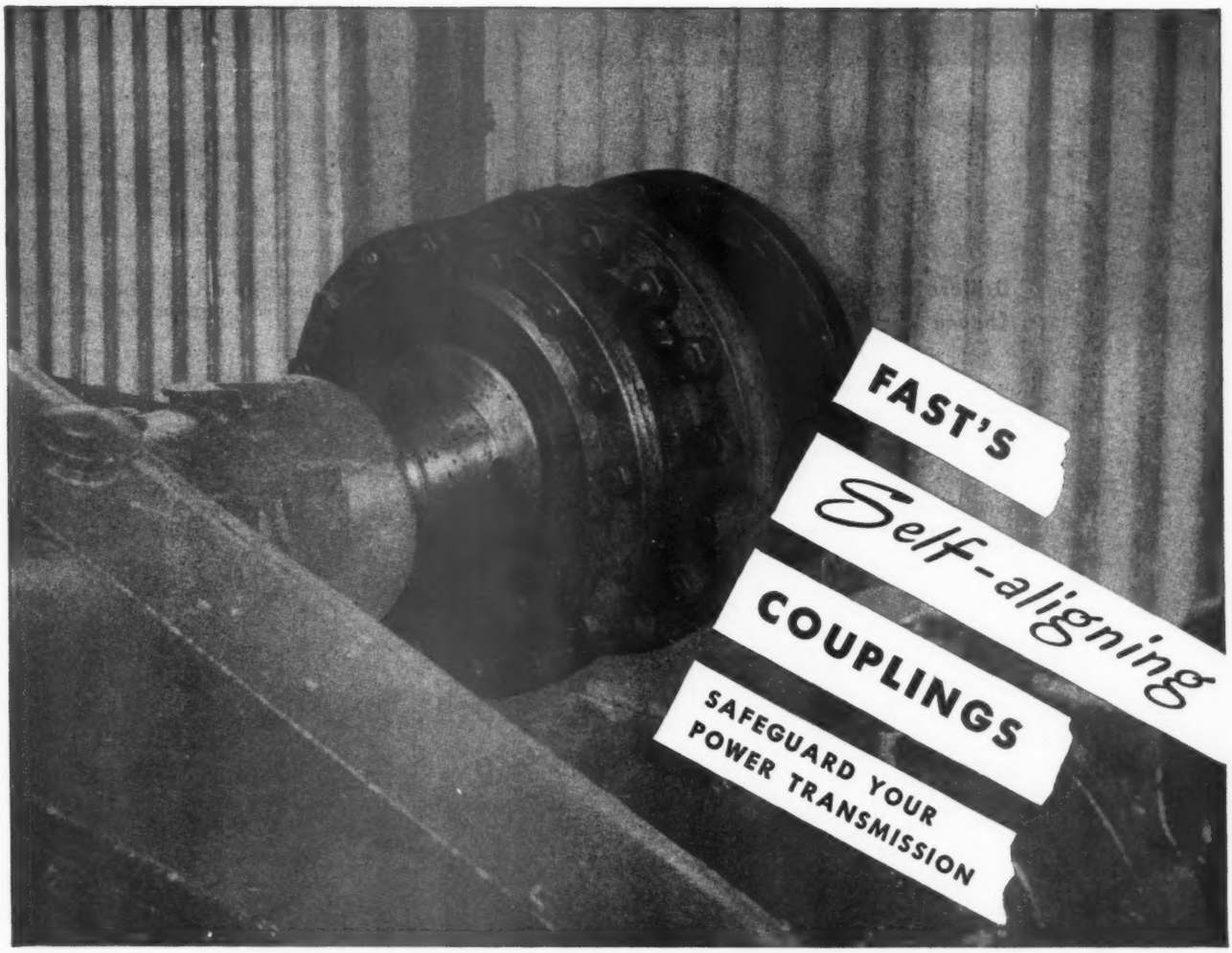


(5) *Mason measure meter*

The new Mason Measure Meter, for measuring depths in oil wells, has been announced by The Mason Measure Meter Company, Tulsa, Oklahoma, of which R. C. Mason is the head. The first measure meter manufactured by this company was placed on the market 26 years ago. The new meter is an improvement over the older type, Mason says, being more accurate and having more universal application. The old style was designed to measure a cable only, whereas the new style meter will measure both a cable and single wire with the same degree of accuracy. The new machine has an attachment to measure a single strand of wire. The cable trolley is removed and the single wire trolley inserted, which takes only 5 min. Thus, it is unnecessary to have a different size measuring wheel to measure a single strand of wire.



The new Mason Measure Meter, which measures both a cable and single wire.



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Here's a story with a moral for every engineer who's looking for *dependable* power transmission.

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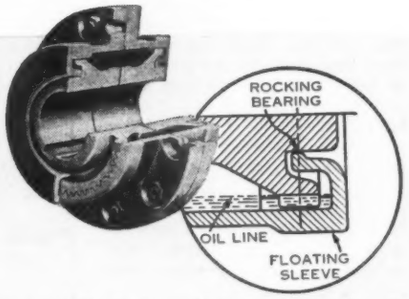
Fast's Couplings have an earned reputation for lasting as long as the connected machines. Their record is the soundest possible guide in specifying couplings for applications where proved dependability is essential. We will be glad to send you a catalog, on request. Bartlett Hayward Division, Koppers Company, Inc., Baltimore 3, Maryland.



Here you see the features that give Fast's Couplings their remarkable dependability. All parts are protected from wear by a positive film of oil. Oil purity is guarded by rocking bearings, located in the one position where they maintain a positive metal-to-metal seal. There are no perishable parts in "Fast's."

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Fig. 247

Fig. 265

Fig. 265—Acme Heavy Duty Collar Buster. Most efficient means of parting string of casing at coupling when pipe is stuck. Quicker. Safer. Saves pipe.

Fig. 247 — Acme Improved Trip Casing Spear of Finger Trip Ring, 3-Slip Type. Exclusive, patented features and extra ruggedness make it the "Big Chief" Pipe Puller.

Fig. 208

Fig. 208 — Acme Side Slot Combination Socket. Known throughout oil world as a most superior tool to fish out tools lost or stuck in hole. If it's STAMINA and RESULTS you want, here 'tis.

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Ben Franklin said, "Beware of the BIG penny's worth", meaning, of course, that you may expect a "boot in the breeches" when you look only at the price-tag before buying . . .

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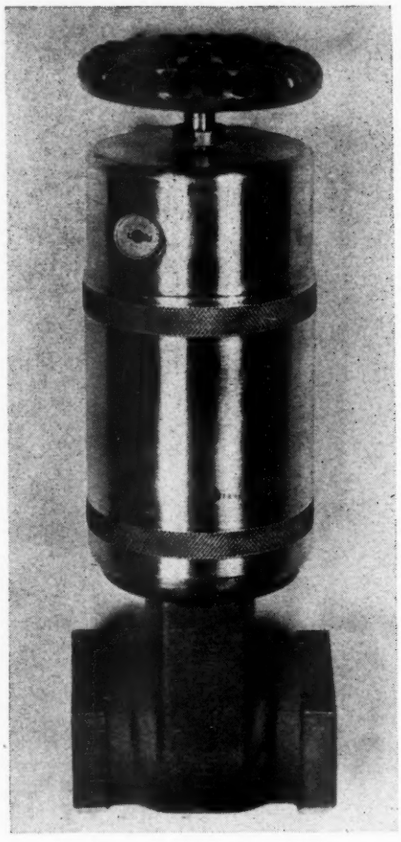
(6) *Valve lock*

Ray Murphy, 1014 North College Street, Tulsa, Oklahoma, has patented a valve lock that can be used on conventional gate or globe valves, making the valve tamper-proof. The lock is built into the valve, and it is possible to lock the valve in position fully closed or fully opened, or at any quarter turn between these positions. Unauthorized or unwanted manipulation of the valve is thus prevented.

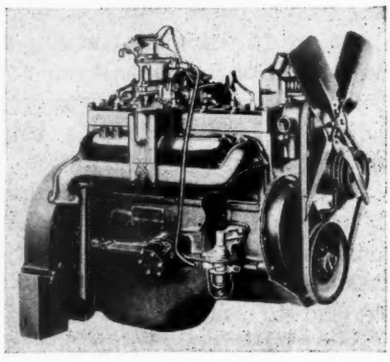
The accompanying illustration shows a gate valve with non-rising stem into which the locking mechanism has been built.



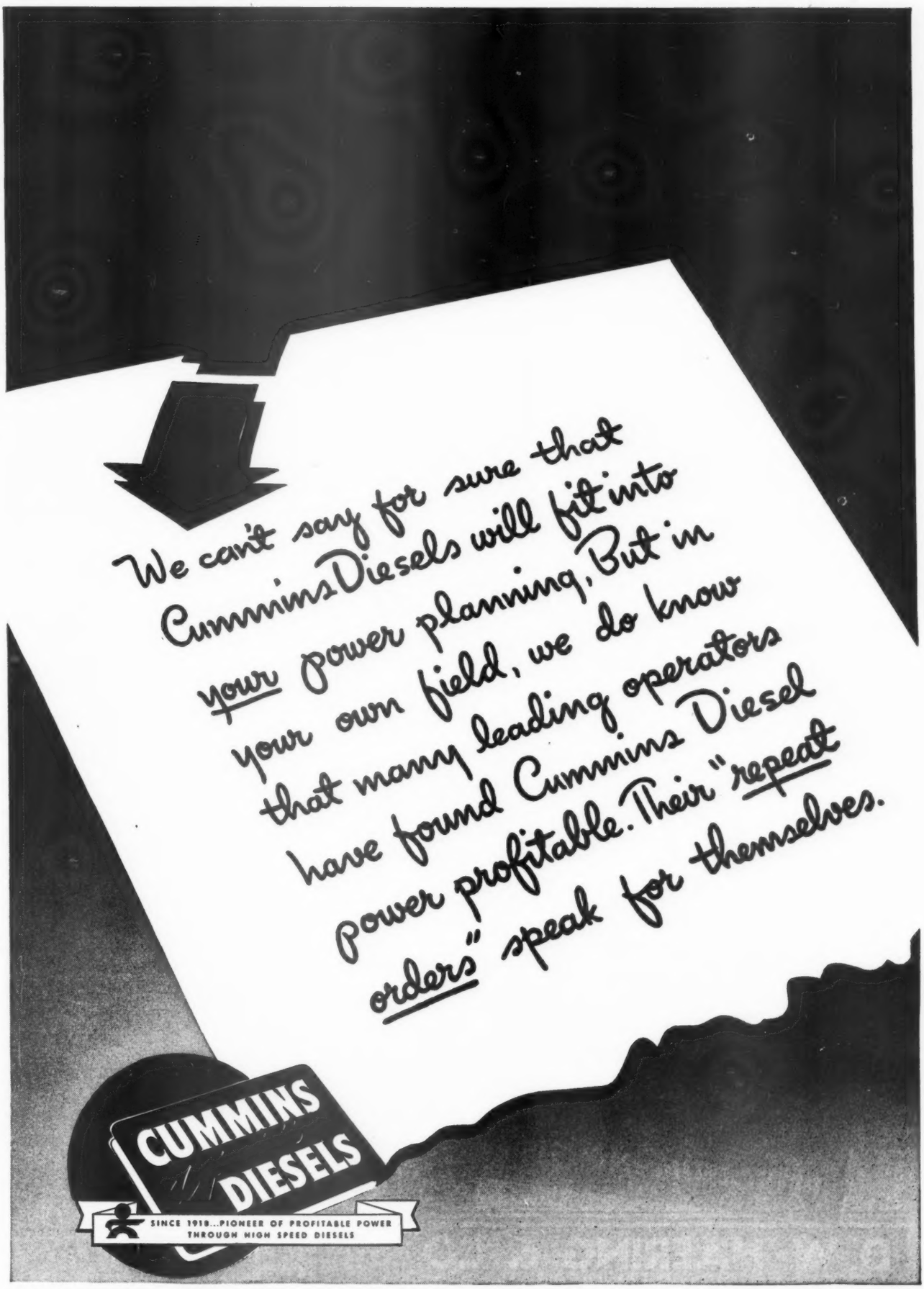
(7) *Industrial engines*

After an outstanding record in many types of power applications during the war, Chrysler industrial engines are again available for the oil industry. With many war-developed improvements, the engines offer increased efficiency and economy.

Chrysler industrial engines are designed, engineered, and built completely in the



Model Ind. 5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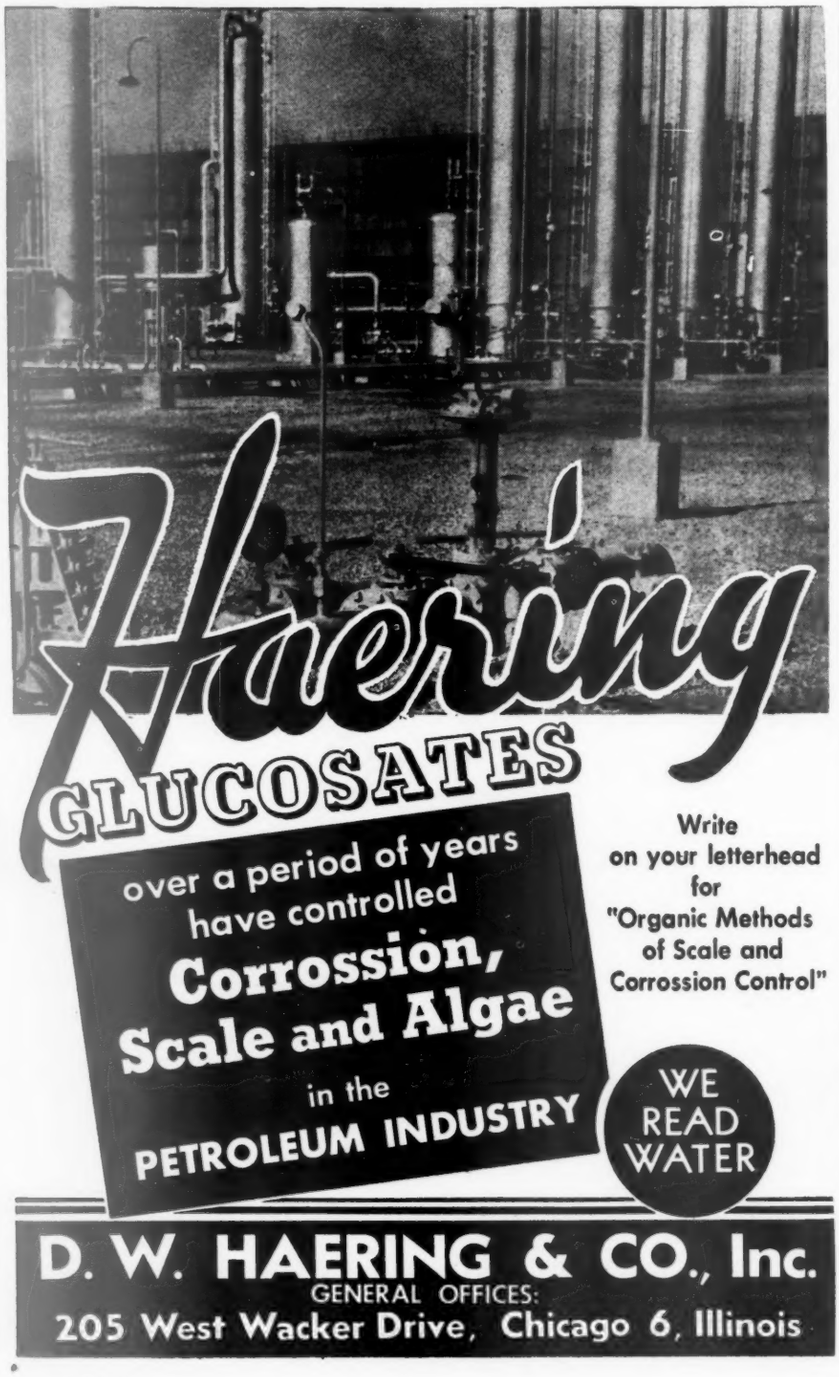
The cylinder block is designed for greatest rigidity. The cylinder bores are made integral with the cylinder block, in order to obtain perfect alignment with the crankshaft, insure against possible water leaks, and obtain the best possible heat transfer. Perfect alignment of cylinder bores and crankshaft insures economical performance and long life. Full length water jacketed cylinder bores assure uniform water temperature in the engine.

Bearings are designed to take 2½ times the stresses actually imposed on them. Exhaust valves are water cooled and oil temperatures are controlled by full length water jackets and high thermal efficiency. These features bring low cost power to users of Chrysler industrial engines, it is asserted.

The flywheel and crankshaft, central points of vibration, have parts balanced to one-half inch ounce. This contributes greatly to a quiet and smooth running engine.

Water temperatures are held to close variations, aided by complete water jacketing with distribution tube directing cooled water from the pump evenly throughout the engine cooling system. Sodium-cooled exhaust valves contribute to long life and efficient operation in very taxing service under sustained load. Intense heat of exhaust gases is the chief factor in valve deterioration and, because the valve head cannot be directly exposed to cooling as can the stem and seat, it becomes extremely hot in service with heat accumulating faster than it can be drawn through the stem and dissipated into the cooling system. Metallic sodium in sodium-cooled valves becomes a liquid at temperatures above 207° F. and conducts heat from head to stem. Sodium-cooled valves are optional equipment for heavy duty work.

Superfinishing of parts subject to wear is one of the principal reasons for outstanding performance and long life of Chrysler industrial engines, it is stated. Superfinished parts have a mirror smoothness that makes virtually perfect wearing surfaces. Other important features are: Chrome-plated piston rings for minimum wear, low fuel consumption and maintenance cost, simplicity and compactness, which save weight and space.



(8) *Traveling block*

Big Four Machine and Supply Company, Clay City, Illinois, recently introduced a new, improved streamlined traveling block and hook for slim hole rigs. Block and hook are combined in one unit. This eliminates conventional bails and becket and results in a more compact assembly that requires less derrick space and handles much easier, according to the manufacturer.

Sheaves are equipped with roller bearings that may be lubricated through high pressure connections on the main axle or pin. Sheave guards conform with the contour of the spacer plates to provide a smooth streamlined appearance. Faster falling speed has been achieved by the addition of cast-iron weight blocks attached to the outer plates.

The full swiveling hook operates on ball thrust bearings and is designed so that it may be locked in position while tripping. To prevent accidental disengagement of elevator or swivel bails, the hook is provided with a positive safety latch. Hook spring is enclosed for protection and longer life.

(9) *Gas trap*

A new series of gas traps of simplified design for efficient separation of gas from oil in individual well installations or as central units for small lease operations has been announced by Fred C. Farmer, manager, meter sales division, Bowser, Inc., Fort Wayne, Indiana.

A patented, positive-acting, float-controlled valve of new design—operating inside the gas trap—is used instead of the conventional back pressure regulator, oil valve, and float flange. With no metal-to-metal seats, no grinding or reseating is necessary. There are no packing glands. It is asserted that the simplified design and negligible maintenance requirements of this new valve make meter installations on individual wells more economical.

Extensive tests have proved that operation is equally satisfactory on vacuum or pressure and that crude spill-over into the gas line is completely eliminated, the manufacturer states.

In operation, crude oil and gas enter the trap. As the liquid level rises, the float be-

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ASSURES COMPLETE REMOVAL OF CEMENT, MUD, SCALE AND BURRS FROM INSIDE OF CASING

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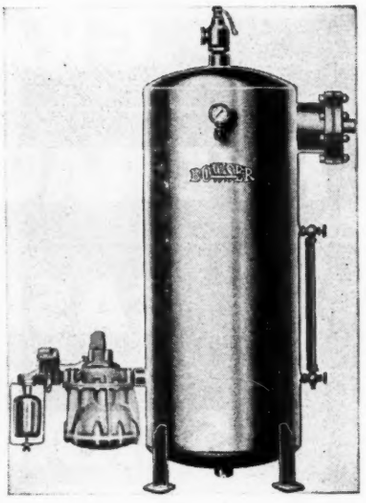
gins to close the gas outlet, which causes pressure to build up inside the trap. When the pressure becomes sufficient to open a spring-loaded valve on the crude oil outlet, the fluid is forced out until the pressure is equalized. Then the liquid rises again and the same procedure is repeated.

These new gas traps are built in two sizes. One has a capacity of 200 bbl. of crude oil and 300,000 cu. ft. of gas and the other 500 bbl. of crude oil and 1,000,000 cu. ft. of gas per 24-hr. day. Working pressures are to 125 lb. Pressure container dimensions are 14 in. diam. by 40 in. shell length and 24 in. diam. by 60 in. shell length in either labeled or unlabeled code construction.

Farmer states that these new gas traps are also an important part of the Bowser automatic well-check system, which includes a proportional sampler and positive displacement oil well meter. The automatic well-check system provides an adequate record of crude oil, gas, base sediment, and water from each well as an accurate basis for the payment of royalties and taxes, analysis and control of operating expense, and quick detection of sleepers or wet wells. The importance of a continuous record of gas-oil ratios for conservation and reservoir study is also emphasized.

The automatic, proportional sampler removes a predetermined quantity from every one-tenth barrel and deposits it in a glass container for periodic collection and analysis. The entire production of liquid enters the sampler. It operates only when the well is producing fluid and the amount of the sample can be regulated.



Measurement of fluid is accomplished by a meter designed especially for oilwell use. With no metal-to-metal contact and few working parts, friction is almost completely eliminated. Three constructions are available: (1) Grey cast iron, (2) brass and bronze, (3) stainless steel. All models have stainless steel and hard carbon internal parts.

Production is under way on all units, Farmer said, and deliveries are expected to begin during the second quarter.

(10) *Mud-O-Graf*

Warren Automatic Tool Company, Houston, Texas, announces an improved and simplified Mud-O-Graf for providing an automatic and continuous record of the weight of mud in the circulating system of a drilling well.

As improved the Mud-O-Graf consists of a weighing unit and a recording unit that are connected by a small rubber hose. The weighing unit can be installed at either the flow line, immediately ahead of the shale shaker, or at the pump suction or at both places. The recording unit or units are placed where the driller can observe the charts conveniently.

HAMER LINE BLINDS

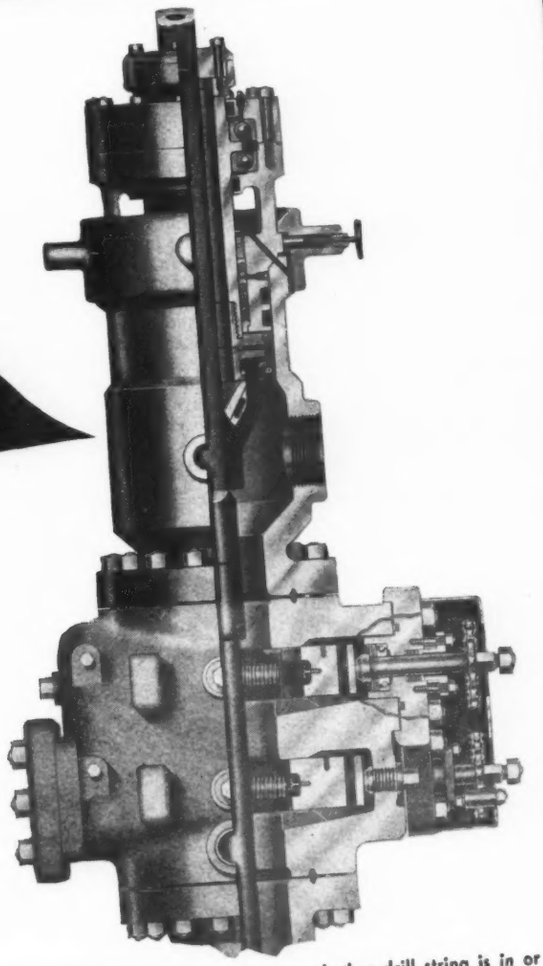
JUST 1 MINUTE from FULL OPEN to FULL CLOSED

and 1 man does it without spilling a drop!

Complete, positive, leakproof shutoff—quick and easy, with minimum man power—that's what this Hamer 4-Bolt Line Blind provides. Designed to handle any material which flows through a pipe line, this strong, simple Line Blind saves time and labor and gives safe, dependable service under all conditions. It is operating successfully on vacuum lines, on high pressure lines, and under high temperatures in many kinds of service. Series 300, 600 in sizes 4" to 16". Write for new engineering bulletin.

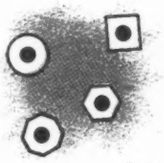
HAMER

Whether It's Round—Square—or Hexagon or Pipe is Flush-Joint—Upset—or Coupled . . . ALL portions of the drill string are CONTINUOUSLY packed-off by . . .

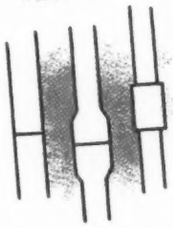


You get complete pressure protection, whether drill string is in or out of the hole, when you use the Shaffer Rotating Blowout Preventer and Stripper in combination with the Shaffer Double Control Gate.

Compare with any other type of control equipment the unique advantages Shaffer engineers have incorporated into the Shaffer Combination Rotating Blowout Preventer and Stripper and you'll readily see why no other equipment offers such far-reaching advancements. For example . . .

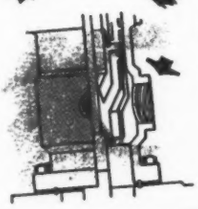


ANY SHAPE This unit maintains a *continuous* seal around all elements of the drill string, *regardless of cross-sectional shape*—and expands or contracts *automatically* to maintain its seal. It not only packs off the round drill pipe, but when drilling, it maintains continuous seal around the kelly, whether square, hexagon or octagon . . . and the stripper unit rotates freely with the kelly so that wear on the stripper rubber is negligible.



VARYING DIAMETERS Except for such abnormally large diameters as the bit and reamers, the unit automatically maintains the same pressure-tight seal around any and *all* diameters in standard drill string assemblies—whether flush-joint, upset or coupled pipe—as well as on the varying diameters of tool joints, subs and drill collars as they pass through the unit.

AUTOMATIC OPERATION Furthermore, it maintains its seal continuously and automatically without any need for applying outside pressure or manual operations of any kind. As the various shapes and diameters pass through the unit, the stripper rubber automatically expands and contracts to maintain a full-circumferential seal at all times and under all operating conditions. The instant a blowout threatens, the control unit is *already* packed-off without the uncertainties or risks of manual operations. And the unit is so designed that increased well pressure only seals the stripper rubber even tighter.



BUILT-IN FLOW CONNECTIONS Another feature—when gas pressure is encountered, there is no need to shut down the well or even stop drilling, for flow connections are built directly into the unit *below* the stripper rubber to permit weighting the mud column while the stripper rubber keeps the well under complete control.

AND CHECK THESE ADDITIONAL ADVANTAGES

No special equipment required: The Shaffer Combination Rotating Blowout Preventer and Stripper operates with the kelly and drill pipe ordinarily used for standard drilling operations. No special drill string equipment or operations are required!

Stripper rubber cannot extrude: The stripper rubber is reinforced by flexible steel latches that form an expandable steel barrier to prevent damage to the rubber by unusually high pressures or large diameters.

Release is quick, simple: When unusually large diameters such as reamers or bits are to be passed through the unit, simply pull a spring latch, turn the Bonnet ⅛ turn and the complete internal assembly can be readily withdrawn.

Cellar-saving compactness: Note the minimum vertical space required by the Shaffer Combination Rotating Blowout Preventer and Stripper. Moreover, built-in flow connections eliminate need for spool or other overflow connections, saving still more space in the drilling riser.

Send for the Shaffer Catalog

This is by no means the complete story on the many unique advantages built into the Shaffer Combination Rotating Blowout Preventer and Stripper. See your nearest Shaffer representative for complete details . . . or write direct!.

See pages 2687 to 2730 of your Composite Catalog for helpful data on the complete Shaffer line.

SHAFFER

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

SHAFFER TOOL WORKS, Brea, Calif. • California Service Shops: Santa Fe Springs and Taft • HOUSTON, TEXAS, 6006 Navigation Blvd. • ODESSA, TEXAS, 1925 W. 2nd St. • OKLAHOMA CITY, OKLA., Acme Oil Tool Co., 1001 S. E. 29th St. • EXPORT SALES OFFICE: Shaffer Tool Works, 30 Rockefeller Plaza, New York, N. Y., U. S. A.

You get complete pressure protection, whether drill string is in or out of the hole, when you use the Shaffer Rotating Blowout Preventer and Stripper in combination with the Shaffer Double Control Gate.

With weighing units installed at both locations the dual record provides a comparison between "cut returns" from bottom and mud being returned to hole. This information is extremely valuable as the well goes deeper and there is the possibility of encountering gas pressure. The dual record also checks the efficiency of equipment used to shake or knock gas out of the mud and proves very helpful when slight variations in weight mean loss of mud to thief formations.

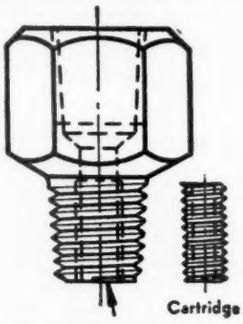
The Mud-O-Graf measures the specific gravity of mud by measuring the differential pressure between two vertically spaced points in a predetermined volume of drilling mud. As the specific gravity of the mud varies, the differential pressure between these two points will vary in direct proportion thereto. These pressures are communicated to the recording unit and recorded on a 24 hr. chart calibrated in pounds per gal or pounds per cubic foot, as the operator desires. Mud enters the weighing unit periodically by means of a vacuum and discharges through release of the vacuum. The time cycle of filling, dumping, and recording is approximately 1½ min.

The improved Mud-O-Graf has no moving parts for actual weighing of mud, requires no air or gas supply, needs no water, requires no flushing out, requires no welding of coupling into mud flow line or discharge hose to mud pits, and requires less time to install and remove, the manufacturer states.

In addition to continuous recording of the mud weight, the Mud-O-Graf graphically indicates all heavy and light streaks in the circulating system, shows duration and relative amount of gas in gassy streaks, indicates how often the hole is filled up when making a trip, eliminates guess work in the use of weighting materials, chemicals and water, shows time of complete circulation, indicates drilling speed and time required for all drilling operations, and enables crew to determine when they can pull a dry string of drill pipe, thereby eliminating time and cost of adding weighting material, according to the manufacturer.

(11) *Cartridge snubber*

A new type snubber, or pulsation dampener, has been developed by the Helicoid Gage Division of American Chain and Cable Company, Inc., Bridgeport, Connecticut. This little device takes advantage of the use of powdered metal through which the pressure medium must pass. The compressed powdered metal is in the form of a cartridge



Cartridge

that can be inserted directly in the gage socket, or in a small separate connecting piece attached to the gage socket.

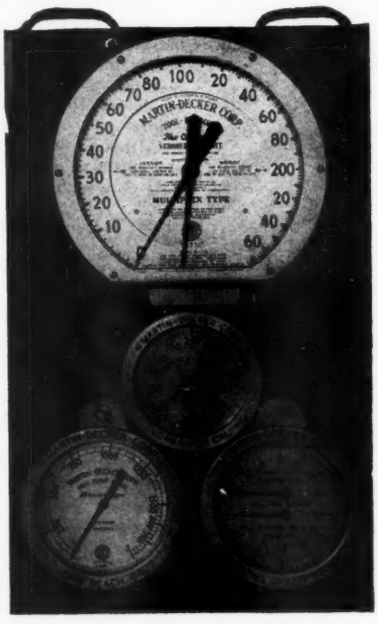
The compressed powdered metal is made in various porosities for air or gas, for water or steam, or for oil.

It has been found that this cartridge snubber is very effective for reducing or eliminating violent pressure pulsations.

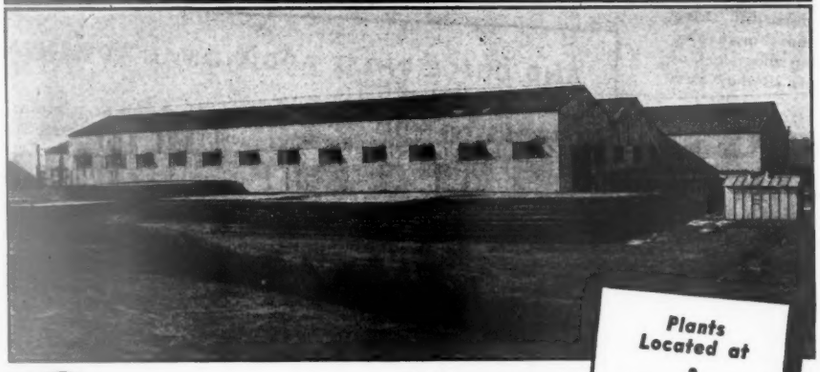
(12) *Weight indicator*

Martin-Decker Corporation, Long Beach, California, has developed a line of Clipper Sealtite weight indicators for use with jackknife, portable, or mast rigs, or for conventional derricks having restricted floor space.

The new Clipper Sealtite weight indicators combine the outstanding advantages of Sealtite construction, heretofore available



AN OUNCE OF PREVENTION
Prevnts Corrosion.
Hill, Hubbell
PROTECTS
YOUR PIPE LINE INVESTMENT

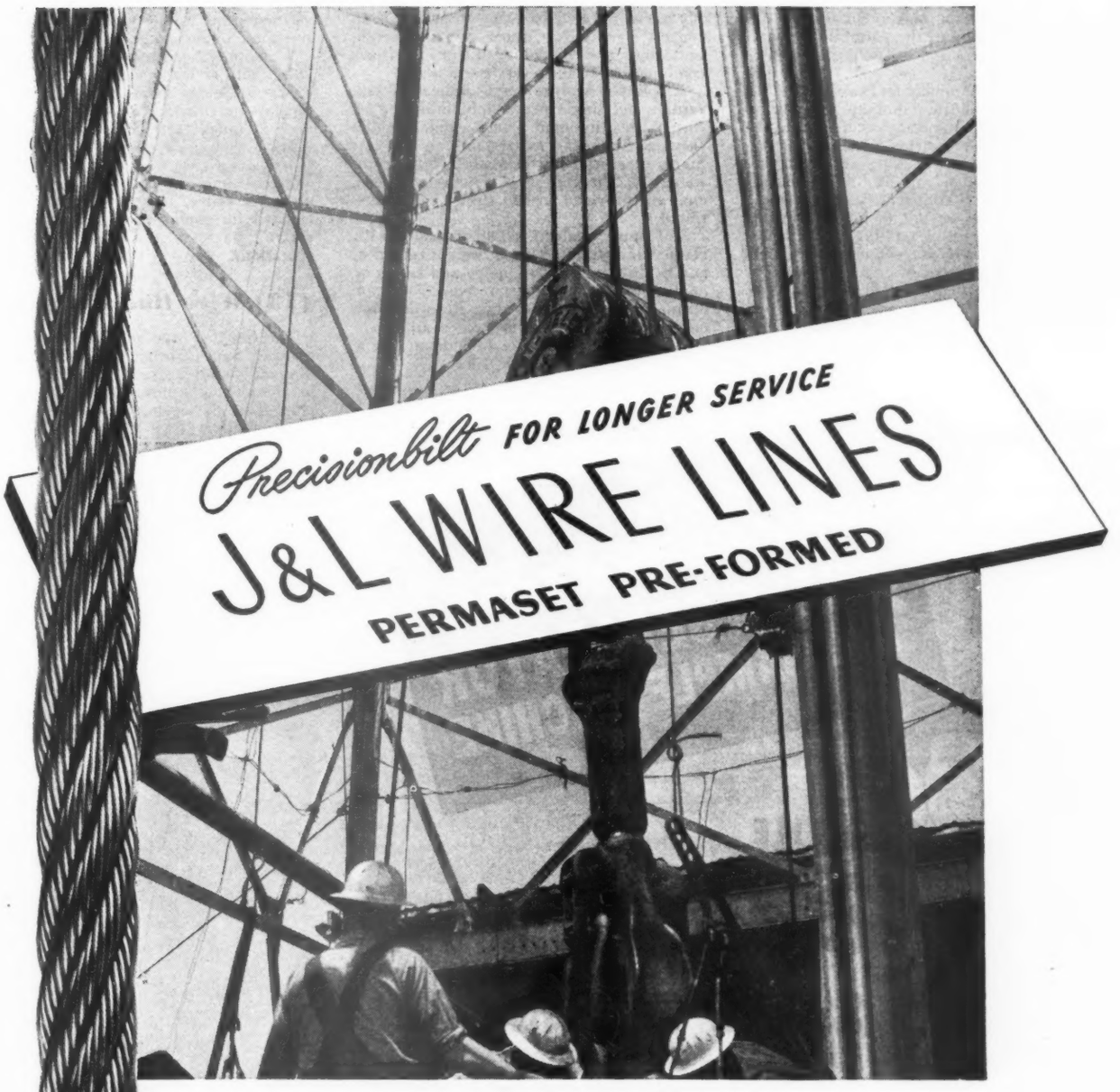


Plants Located at
• Lorain, Ohio
• Girard, Ohio (Youngstown, O. switching area)

Factory applied

Factory applied coating and wrapping on steel pipe with perfect BOND is truly "An ounce of prevention." It prevents corrosive deterioration of pipe, it prevents frequent shut downs and expensive repairs. "A pound of cure" is needless expense because of "slip-shod" processing. Protect a good investment with good pipe protection—HILL-HUBBELL pipe protection.

GENERAL PAINT CORPORATION
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE: SAN FRANCISCO, CALIFORNIA, U. S. A. •



Your log book will show improved rope service with a resultant lower cost when you use J&L Precisionbilt Wire Lines. They are made of J&L Controlled Quality steel by men who have the experience and ability to produce the best rope for the job. For even greater service, order J&L Permaset Pre-formed Wire Lines—pre-forming gives them extra flexibility and resistance to wear.

J&L STEEL

JONES & LAUGHLIN STEEL CORPORATION

GILMORE WIRE ROPE DIVISION

PITTSBURGH 30, PENNSYLVANIA

J&L *Precisionbilt* PERMASET PRE-FORMED WIRE ROPE

only in the Martin-Decker Sealtite drilling control unit, with all the portability characteristics of the Clipper Toolpusher model, it is stated.

Besides being quickly and easily installed, the Clipper Sealtite eliminates the drawbacks of direct mounting. Installation at the driller's position protects the gauge mechanism from the terrific whip and damaging vibration occasioned by deadline mounting, it is asserted. Permanent sealing of the Clipper Sealtite at the factory eliminates leaks, pumping up or refilling, and enables the instrument to remain connected even during transportation and storage. Special non-freezing, non-corrosive weight indicator fluid provides temperature compensation, insuring highest accuracy under all climatic conditions. Hose, diaphragms, and entire assembly are stored in a 16 in. by 16 in. by 26 in. rugged steel box. Clipper Sealtite weight indicators are available in the following combinations to suit every purpose:

1. Clipper Sealtite weight indicators with vernier and single pen weight indicator recorder, Sealtite mud pump gauge, double vacuum gauge, and rotary table tachometer. Storage facilities for the Sealtite equipment, weight diaphragm, mud diaphragm, hose, etc., are provided in the steel case. (Illustrated.)
2. Clipper Sealtite weight indicator with vernier and with or without weight recorder, and Sealtite mud pump gauge and single or double vacuum gauge for power rigs or torque gauge for steam rigs. Recorders for mud and torque gauges are also available.
3. Clipper Sealtite weight indicator with vernier, either with or without recorder, Sealtite mud pump gauge, and tachometer.
4. Clipper Sealtite weight indicator only, either with or without recorder.

Martin-Decker Clipper Sealtite weight indicators provide the convenience and advantage of quick installation and easy portability with rugged construction, high sensitivity, and complete accuracy in indicating and recording drilling information, the manufacturer states. They are especially recommended for shallow wells, running tubing, setting packers and liners, and fishing operations.

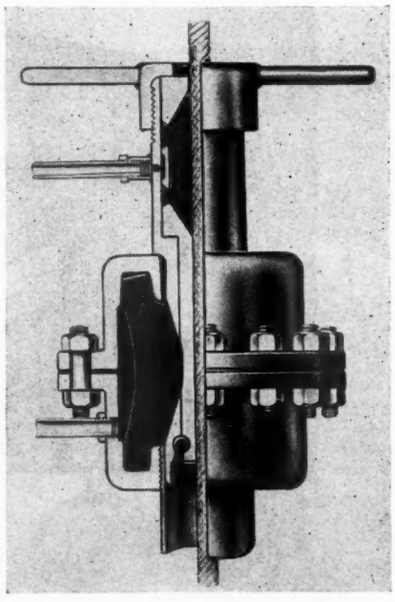
THE
Thompson
SHALE SEPARATOR
AND SAMPLE MACHINE
THE
Best ALL 'ROUND
SHALE SEPARATOR!
UNLIMITED CAPACITY is found in New Model DW. SELF-MOTIVATED . . . operates from flow of mud. RECONDITIONS MUD by removing shale and abrasives. ACCURATE SAMPLES provided. You Need Thompson as Standard Equipment.
THOMPSON TOOL CO.
IOWA PARK, TEXAS

(13) *Wire line stripper*

The Regan Forge and Engineering Company of San Pedro, California, announces the manufacturer of its new wire line stripper, employing a new principle in line stripping. This device has a wiper-rubber confined within a steel housing. When acted upon by an outside source, the rubber contracts, closing around the line. Source of pressure may be CO_2 gas, field gas, nitrogen, or any other non-oxidizing gas.

Controlled pressure is used to maintain a constant contact between the rubber and wire line at all times, insuring an orderly and clean wiping job.

The stripper has been used on swabbing jobs, bailing, wire line coring, and well surveying jobs.



(14) *Three-way valve*

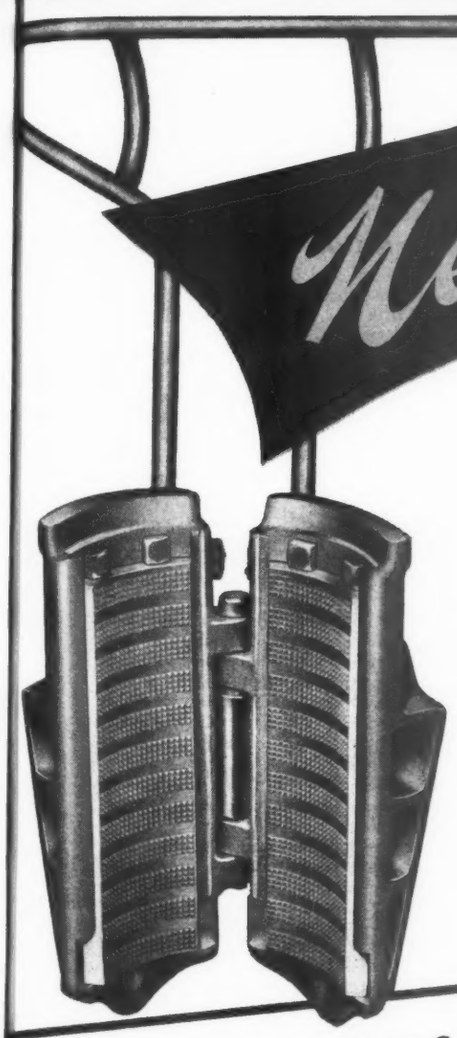
Employing a flexible molded synthetic rubber tube, encased within a bakelite body, the new Grove Flex-tube *three-way* valve is designed for handling all types of fluids, including gases, chemicals, and liquids. It is especially suited for hydraulic or pneumatic cylinder operation.

Due to its unrestricted straight flow characteristic, this unit is most satisfactory for controlling viscous or solid-carrying fluids, it is stated. Non-metallic construction permits the handling of highly corrosive or erosive liquids or gases. Manual operation, by means of an over-center cam, opens and closes the ports at each half turn of the handwheel. A special self-locking feature assures positive tight shut-off over extended periods of time. Available in ⅛ in. and ¼ in. I.P.S., these new type valves are provided for working pressures up to 250 lb., and maximum temperatures of 150° F.

Baash-Ross News

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

OUR 26th YEAR



New! BAASH-ROSS "2MB" TWO-MAN ROTARY SLIPS

One Body Fits Many Pipe Sizes
Segmented Liners Cut Maintenance
Light Weight—Balanced Design
Protective Safety Handles

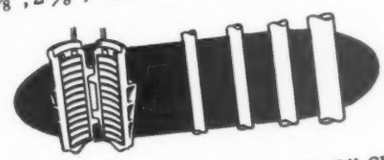
FOR those operators who prefer a two-man rotary slip, Baash-Ross has developed the new "2MB" Rotary Slips which embody far-reaching advancements that insure better slip performance, greater crew efficiency, minimum maintenance and inventory costs.

"2MB" Slips are a two-man version of the famous Baash-Ross "DU" Rotary Slips that have proven so popular with operators everywhere. "2MB" Slips incorporate the same unique advantage in that each body size fits a wide range of pipe diameters by simply changing liners. Segmented liners are another important feature that cuts inventory costs, insures better grip efficiency and minimizes liner replacement. "2MB" Slips are light in weight and balanced for easy handling and maximum convenience to the crew. Their safety handles not only have guards to protect the workmen's hands, but also have large loops that safeguard against the Slip being dropped into the hole through the master bushing.

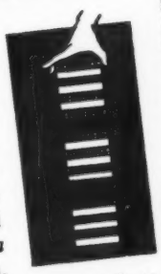
The new "2MB" Rotary Slips are available in three basic body sizes—4-½", 5-9/16" and 7"—*and by simply changing liners,* these three body sizes fit all pipe diameters from 2-⅜" to 7". They are also available in "Short" and "Long" types to meet every load requirement. The "Short" type has a gripping surface 12" long and is recommended for all drill strings to 8,000 ft. The "Long" type has a gripping surface 16" long and is recommended for the deepest wells and heaviest drill strings. Check over these important features . . .

"2MB" Features That Save Time, Boost Efficiency!

MONEY-SAVING ADAPTABILITY: With "2MB" Slips there is no need to stock a different-sized slip body for each different size of pipe used in your drilling operations. *By simply changing the liners*—a quick, inexpensive operation—the same "2MB" Body can be quickly adapted to fit a wide range of pipe sizes. For example, by changing only the liners, the 4" Body fits 2-⅜", 2-⅞", 3-½" and 4" pipe!



SEGMENTED LINERS: Liners in "2MB" Slips are in 4" segments that are rigidly locked into the body to form a continuous gripping surface. No need to stock separate liner lengths for 12" and 16" slips. *Three* 4" segments make a 12" liner—*four* segments make 16" liner. This feature cuts inventory costs to the bone!

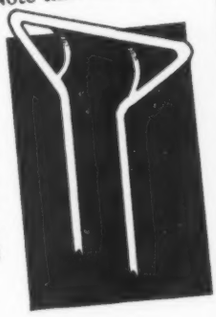


Also, if liners wear unevenly, there's no need to throw away the entire liner when one portion becomes worn. Simply switch or invert worn with unworn segments for additional liner life *without replacing a single part.* Or, if badly worn, replace only the worn segments and continue to get additional life from the other segments. You get longer liner life at much lower cost!

LIGHT WEIGHT, BALANCED DESIGN: Note how the body sections are cored out to eliminate weight without sacrificing strength. "2MB" Slips have ample strength for the heaviest service. Yet their unusually light weight and balanced handling reduces crew fatigue to a minimum and speeds round trips.

RIGID LINER SUPPORT: The liner segments are rigidly supported in the slip body so that all working stresses of both supporting the pipe and of rotating it when breaking out joints are transmitted *directly* to the slip body. There are no retaining members to become sheared or broken and drop the liners in the hole.

FULL SAFETY HANDLES: Note that the safety handles not only embody guards to protect the crew against pinched hands, but they also have wide loops that safeguard against the slips being dropped through the table or into the hole . . . both important safety features!



The above are only typical of many "2MB" Slip advancements. Get complete details on these new Baash-Ross Two-Man Rotary Slips from your nearest representative—or write direct!

TRADE LITERATURE

Publications listed are sent free upon request.

(15) *Oil well pump plungers*

A bulletin released by John N. Martin, Manufacturer, Tulsa, Oklahoma, discusses Martin oil well pump plungers. Illustrated descriptive matter tells how the plungers work, advises on selection of the proper plunger, and shows how they should be installed.

(16) *"Oilwell bulletins"*

Oil Well Supply Company, Dallas, Texas, has recently issued four bulletins on various items of equipment, as follows: Bulletin E2-446 on the Witte horizontal gas-gasoline engine; bulletin U15-1245 on the TC-28 twin-crank pumping unit; bulletin R5-1245 on the 17½-A and 17½-B oilbath rotaries and bulletin P 16-1145 on the No. 18-P power slush pump.

(17) *Chemical treatment drilling mud*

"Chemical Treatment of Drilling Mud" is the title of a booklet issued by American Cyanamid and Chemical Corporation, New York City. This booklet contains, for ready reference, a digest on chemical treatment of muds, featuring such subjects as mud properties, testing methods, practices for fast, safe well drilling with rotary tools, surface systems for mud handling, control methods relating to viscosity, water loss, etc., and a description of chemical compounds that are used effectively in maintaining necessary controls.

(18) *Copes flowmatic regulator*

Bulletin 449, "Controlling Feed Flow and Water Level on Chemical Plant's Foster Wheeler Type S-A Steam Generator," has been released by Northern Equipment Company, Erie, Pennsylvania. The controlling equipment discussed is the Copes Flowmatic regulator.

(19) *Emsco slush pump*

A two-page folder issued by Emsco Derrick and Equipment Company, Los Angeles, California, illustrates the Emsco slush pump in cutaway view and also gives comparative specifications of the various types of Emsco pumps.

(20) *Care of sucker rods*

"Care and Handling of Sucker Rods" is the title of a booklet published by the S. M. Jones Company. Unloading sucker rods from railroad cars or trucks, storing, loading and hauling to the well, running the rods, servicing, etc., are some of the phases of careful handling discussed in this booklet, which is well illustrated. The booklet is the fifth edition, and is said to have been very useful in the training of new personnel.

(21) *Wire rope making*

The development of wire rope making over the years is given chronologically and illustrated in a folder issued by Macwhyte Company, Kenosha, Wisconsin.

(22) *Wire line maintenance*

American Cable Division of American Chain and Cable Company, Inc., Bridgeport, Connecticut, has issued a booklet on the selection and maintenance of wire line that should be of great value to members of the oil industry. "This booklet has been prepared to help men in the petroleum industry select the correct wire lines and to summarize many maintenance suggestions," says an introductory statement. Careful perusal of the book reveals that it does this in a most satisfactory manner. Numerous pictures show the many uses for which wire rope is utilized and graphically illustrate the best methods of handling to assure its long usage.

(23) *Manual on salts in petroleum*

The Petroleum Rectifying Company announces the publication of the "Petreco Manual on Salts in Petroleum." This manual, a revision of a booklet published some years ago, then entitled "Determination of Salts in Crude Oils," has been prepared for complimentary distribution to the members of the industry in response to many requests —the supply of the original publication having long been exhausted. Based on extensive analytical work in the Petreco laboratories, the Petreco Manual describes in detail the best methods of analysis for salts and other impurities in petroleum. Also included is a fund of general information on impurities in crude oils and the character of the problems involved in their determination.

(24) *Castings of Circle L 9 steel*

A new bulletin on castings made of Lebanon Circle L 9 steel has been issued by the Lebanon Steel Foundry, Lebanon, Pennsylvania.

(25) *Otiscoloy steel*

Otiscoloy is one of the most interesting and important of the large and diversified family of the Jones and Laughlin Steel Corporation controlled quality steels. Otiscoloy is a high-tensile, low-alloy steel that is readily weldable and easily fabricated, and corrosion resistant steel, having substantially greater strength than the standard carbon structural steels, according to J & L officials. The Jones & Laughlin Steel Corporation recently published a very attractive 16-page 2-color illustrated Otiscoloy booklet, giving technical information, suggested applications, and other useful information of their new weight-saving steel.

(26) *Guide to electronics*

To show how electronics is already speeding production, saving time and materials, and promoting safety in industrial plants, and to suggest how owners of other factories can put electronics to work, the Westinghouse Electric Corporation has published a new booklet, "The Business Man's Guide to Electronics." The booklet explains the six fundamental functions of electronic tubes, rectifying, amplifying, generating, controlling, counting and sorting, and inspecting, and describes the tubes required for each function.

(27) *Oilfield transportation*

Ingenious methods of moving material and supplies, developed in the oil industry where transportation is a foremost factor in successful, profitable production, are featured in a new booklet, "Oilfield Transportation With Caterpillar Diesel Power."

The eight-page booklet dramatically portrays how bulky spudders are skidded from one location to another; how drilling engines, mud pumps and floors are hauled into position; shows the re-location of derricks; how derrick timbers, cable tool rigs, tool sheds and steel tanks are transported quickly and easily to the scene of operations. It also shows how land must be cleared, access roads built and slush pits dug—all jobs where power, traction and stamina become part and parcel of economic operation.

(28) *Pneumatic transmitter*

A new bulletin, 55-A, recently released by Fischer and Porter Company describes in considerable detail pneumatic transmitting accessories that may be applied to any Rotameter type flow rate instrument. The transmitter consists of an unusual indissoluble magnetic clutch that picks up the Rotameter float movement and translates it into external angular motion. Attached to the magnetic follower beam is a newly designed air pilot with a linear pressure output characteristic. The Rotameter readings may be transmitted at great distances to recorders, indicators, or recorder-controllers equipped with pressure bellows type pneumatic actuating motors. This accessory for Rotameters eliminates the need for electrical transmission means and is being applied in locations where explosive volatile gases are present.

(29) *Flow indicators*

Full detailed descriptions of Schutte and Koerting flow indicators including sectional drawings of construction features, operation principles, applications and characteristics of the different types are available in a new Bulletin, 18-W.

(30) *Bentube evaporators*

A new bulletin on evaporators for distilling boiler feed make-up has been printed by The Griscom-Russell Company. Besides describing and illustrating many different types of G-R Bentube Evaporators for various capacities and pressures, the bulletin contains several sections of special interest to plant engineers and executives, including an explanation of the functions of evaporators, the benefits obtained by their use, the different types of evaporator systems, and their association with plant heat balance. The bulletin is profusely illustrated with photographs and diagrams of the various types of G-R Bentube Evaporators and their details of design, including the patented scale-shedding Bentube heat transfer elements, and also many heat flow diagrams of plants equipped with evaporator systems.

(31) *Floor maintenance folder*

"It's easy to Repair Rough, Rutted Floors" is the title of a new floor maintenance folder published by the Stonhard Company. This pamphlet will prove extremely interesting to all petroleum plant owners, managers and engineers, for it deals extensively with floor patches and overlays that are lastingly resistant to oils, greases, and acids. It describes how floors subjected to such conditions are quickly and permanently repaired or overlayed by unskilled labor.

(32) *Unibolt catalog*

Among the new items featured in Thornhill-Craver Company's new catalog, which has just come from the press, is the Unibolt welding neck coupling for use on high pressure steam lines to prevent thread leaks, an adjustable wing valve or choke with micrometer adjustments for precise flow control, and the Unibolt "X" type flow bean. The latter is an innovation in positive flow beans in that its orifice sizes are gauged in increments of 10 per cent of well flow. Flow charts are carried in the catalog to enable the operator to correlate between ordinary fractionally drilled beans and "X" type beans.

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 107

A VALUABLE and regular feature of *The Petroleum Engineer*, the Continuous Tables, now in their eighth year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive in the October, 1945, issue; 101-103, inclusive, in the January, 1946, issue, and 104-106, inclusive, in the April, 1946, issue.

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Hazard Wire Rope Division of American Chain & Cable Co., Inc.	(sheet 4)	278	May	P 514.5
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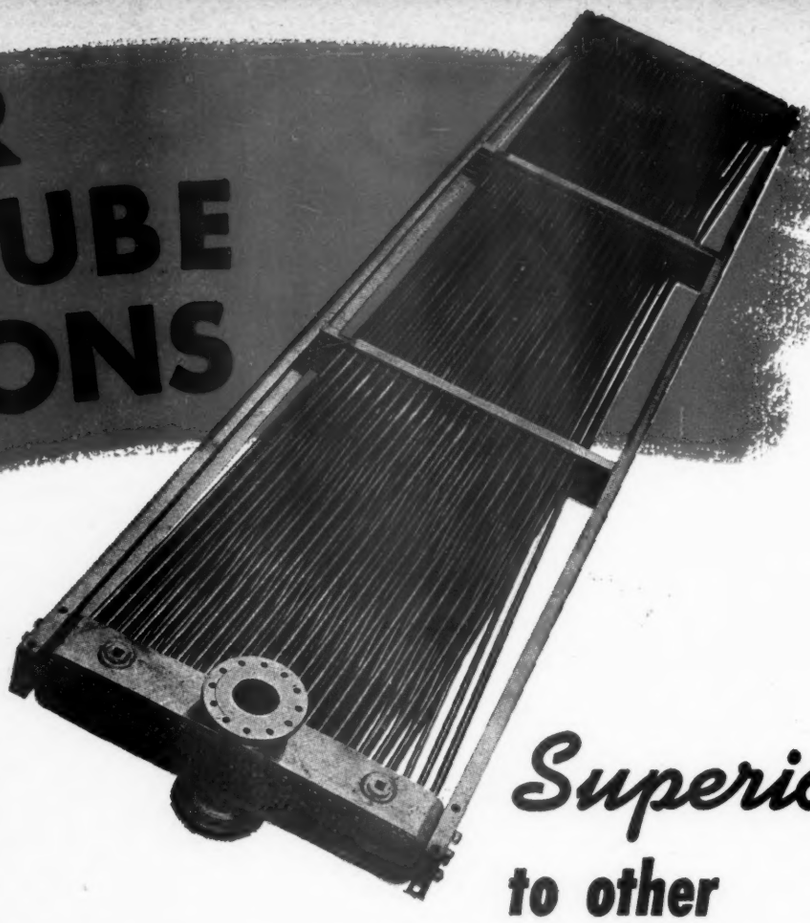
G-R BENTUBE SECTIONS



Superior to other atmospheric condensers and coolers because . . .

Their greater compactness . . . sturdiness . . . ease of installation . . . low maintenance expense . . . high salvage value . . . and their exclusive SCALE-SHEDDING feature which maintains rated heat transfer rates without requiring manual de-scaling of tubes . . . these features have made G-R Bentube Sections by far the most widely used atmospheric condensers and coolers for hydrocarbon vapors and petroleum derivatives.

These units have replaced pipe coils, cast iron sections, straight tube sections, shell-and-tube units, and other types of heat transfer apparatus in installation after installation; and today, more than 10,000 Bentube Sections are in service.

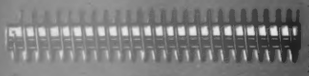
For complete description of these units, write for our Bulletin 1601.

THE GRISCOM-RUSSELL CO.
285 Madison Ave., New York 17, N. Y.

ONLY G-R BUILDS THIS WIDE VARIETY OF HEAT TRANSFER APPARATUS

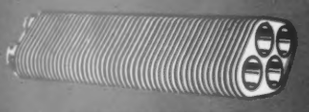
SHELL and BARE TUBE
Heaters, Coolers, Condensers, Heat Exchangers

G-FIN
Longitudinal-finned elements for greater heat conductivity



K-FIN
Helical-finned elements for vapors and gases

BENTUBE SECTIONS
with scale-shedding elements for hard or salt water



TUBEFLO SECTIONS
Non-clogging design for residuum and other dirty fluids

GRISCOM-RUSSELL
Pioneers in Heat Transfer Apparatus

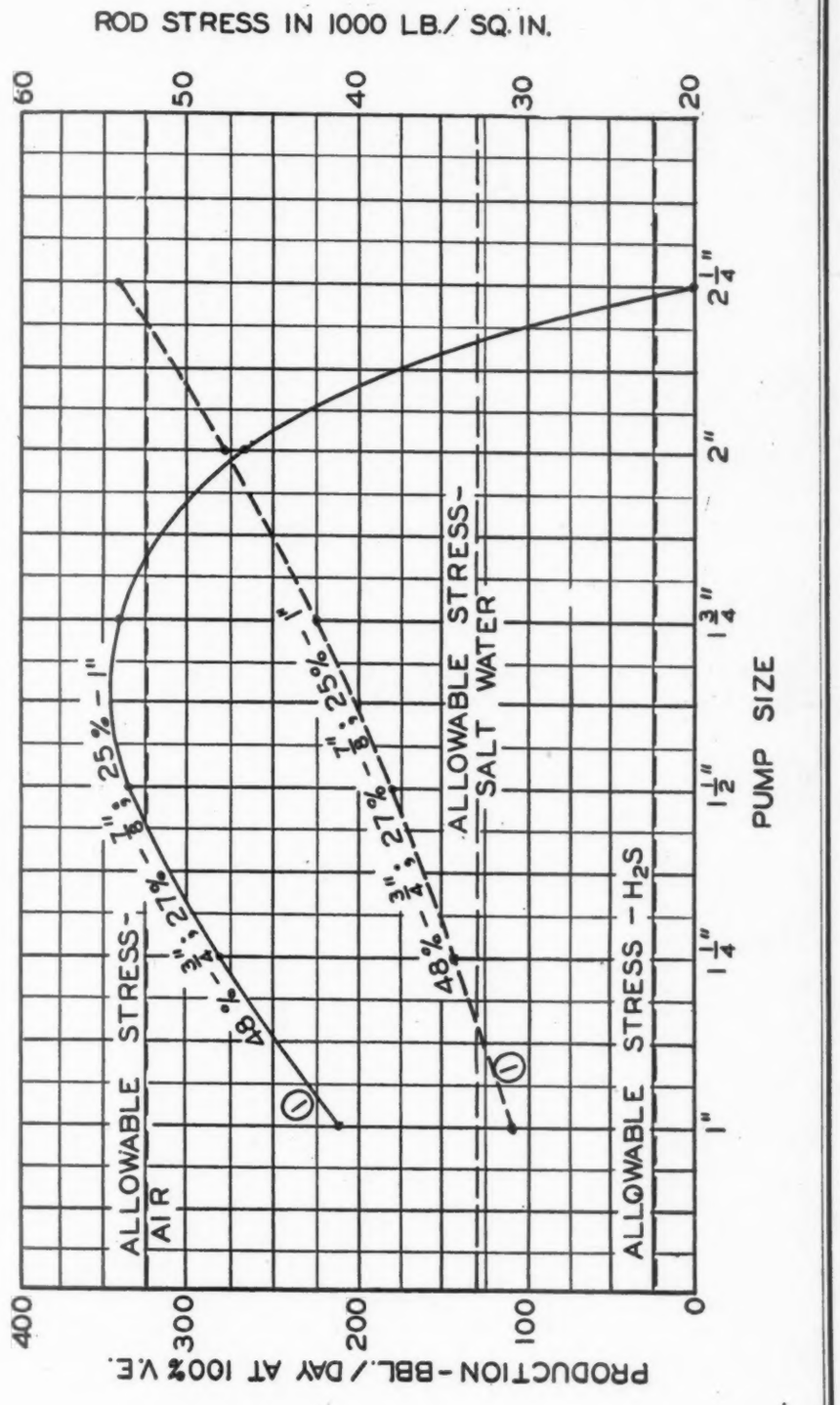
PLUNGER AND ROD SIZE SELECTION CHARTS FOR DEEP WELLS

This series of plunger and rod size selection charts have been designed to illustrate roughly the load and plunger travel conditions, peak torque and approximate horsepower requirements that should be anticipated in pumping deep wells. Mills' formula was used in calculating the polished rod load, and Sloneger's formula was used in calculating the peak torque. The production of the pumps has been corrected for sucker rod stretch, but not for volumetric efficiency. The specific gravity of the fluid pumped is assumed to be 1.00. The "allowable stress" is necessarily an arbitrary endurance limit, and, if exceeded, an unduly high number of rod failures may be anticipated.

—*Chart by H. E. Berg, Petroleum Engineer, Tide Water Associated Oil Co., and W. H. Minor, Lufkin Foundry & Machine Company.*

The solid line curve represents the production, and the dashed line curve represents the stress for the combination rod string shown.

Conditions for Curve No. 4 (below):
Pumping depth, 8,000 ft.
Strokes per min., 20.
Length of stroke, 74 in.
Size of tubing, 3 in.
Peak polished rod load = 0.78 × rod stress shown.



For Absolute Uniformity...

DID YOU KNOW that the preforming process stepped up wire rope quality all along the line? To make preformed rope the manufacturer has to hold to close tolerances, exercise precise controls. That fine precision has made *all* wire rope, preformed or non-preformed, better than it was prior to the advent of preforming. Hazard has had long experience in these exacting methods. That is why Hazard LAY-SET Preformed, as well as Hazard non-preformed ropes, is uniform—reel after reel. Buy Hazard, and you get uniform quality—now and always. Buy Hazard LAY-SET Preformed Wire Rope made of Improved Plow Steel.

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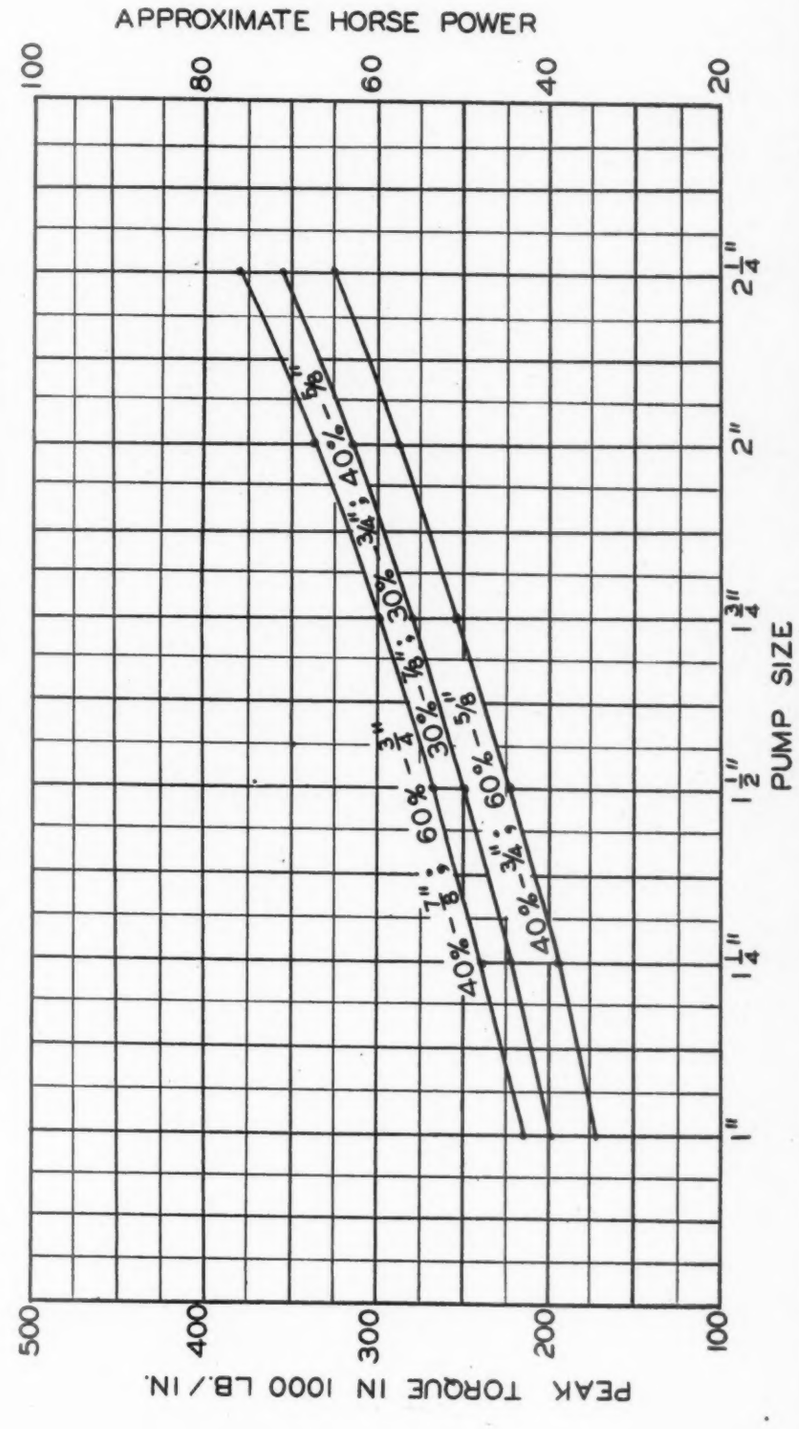
In Business for Your Safety

PLUNGER AND ROD SIZE SELECTION CHARTS FOR DEEP WELLS

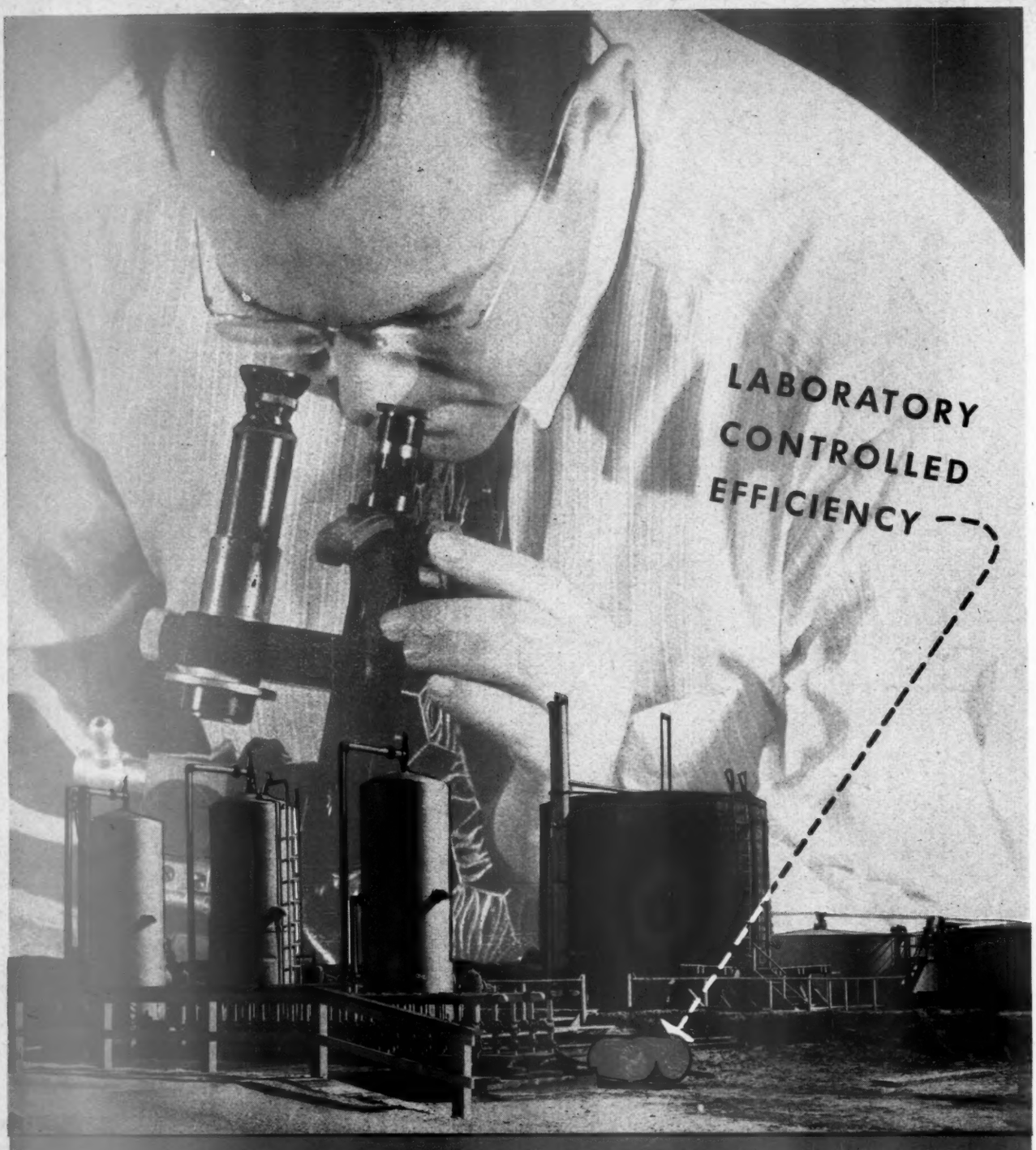
This series of plunger and rod size selection charts have been designed to illustrate roughly the load and plunger travel conditions, peak torque and approximate horsepower requirements that should be anticipated in pumping deep wells. Mills' formula was used in calculating the polished rod load, and Sloneger's formula was used in calculating the peak torque. The production of the pumps has been corrected for sucker rod stretch, but not for volumetric efficiency. The specific gravity of the fluid pumped is assumed to be 1.00. The "allowable stress" is necessarily an arbitrary endurance limit, and, if exceeded, an unduly high number of rod failures may be anticipated.

The curves below show the peak torque and approximate horsepower requirements for the three combination rod strings shown on Sheet 1, P 514.5, published in the April, 1946, issue of *The Petroleum Engineer*.

Conditions for Curve No. 5 (below):
Pumping depth, 6000 ft.
Strokes per min., 20.
Length of stroke, 74 in.
Tubing size, 2½ in.
Specific gravity of fluid, 1.00.



—Chart by H. E. Berg, Petroleum Engineer, Tide Water Associated Oil Co., and W. H. Minor, Lufkin Foundry & Machine Company.



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The Modern Emulsion Breaker

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Visco Products Company is authorized to manufacture and sell Visco Oil Treating compounds for use in the breaking and resolving of oil emulsions, and to grant licenses for such use, under the following United States patents: 1,860,562; 1,860,563; 1,913,350; 1,977,259; 2,050,637; 2,050,640; 2,206,589; 2,214,783; 2,214,784; 2,235,189; 2,247,811; 2,247,812; 2,318,034; 2,318,035; 2,321,056; 2,335,554. Re. 20,717 and patents pending. Any purchaser of Visco oil treating compounds is authorized to use the same in the breaking, breaking and resolving of oil emulsions in accordance with the above patents. The royalty for such use is included in the purchase price. Visco Products Company is authorized to and is willing to grant licenses on a royalty basis, to oil companies, and to others desiring to practice the patented subject matter, under any and all of the above patents, permitting the user to purchase the oil treating compounds at will from any vendor, and to prepare the compounds for use under the above patent or patents, at a royalty charge of 50 cents per barrel.

HYDROCARBON THERMODYNAMICS

FUNDAMENTAL CONCEPTS OF THERMODYNAMICS

FIRST LAW - CONSERVATION OF ENERGY

$\Delta E = Q - W$; ΔE = CHANGE IN INTERNAL ENERGY OF SYSTEM

Q = HEAT ABSORBED BY SYSTEM

W = WORK DONE BY SYSTEM = $\int PdV$ FOR BATCH PROCESS, $\int VdP$ FOR FLOW PROCESS

$H = E + PV$; DEFINITION OF ENTHALPY

$\Delta H = \Delta E + \Delta(PV)$; $\Delta(PV) = \int PdV - \int VdP$ = FLOW WORK

SECOND LAW - DEGRADATION OF ENERGY

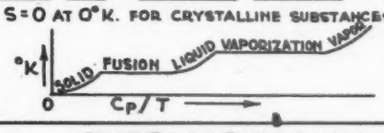
ENTROPY $S = Q/T$; OR INFINITESIMALLY $ds = dq/T$

$$\left(\frac{\partial S}{\partial T}\right)_V = \frac{C_v}{T} \quad ; \quad \left(\frac{\partial S}{\partial T}\right)_P = \frac{C_p}{T}$$

$$dS = \frac{C_p}{T}dT - \left(\frac{\partial V}{\partial T}\right)_P dP$$

THIRD LAW - ABSOLUTE ENTROPY

$S = 0$ AT $0°K$. FOR CRYSTALLINE SUBSTANCES



SPECIFIC HEATS

$$C_p = \left(\frac{\partial H}{\partial T}\right)_P \qquad C_v = \left(\frac{\partial E}{\partial T}\right)_V$$

$$\left(\frac{\partial C_p}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P ; \quad \left(\frac{\partial C_v}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V$$

$$C_p - C_v = -T\frac{\left(\partial V/\partial T\right)_P^2}{\left(\partial V/\partial P\right)_T}$$

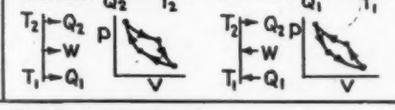
JOULE-THOMSON COEFFICIENT

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H = \frac{T\left(\partial V/\partial T\right)_P - V}{}$$

$$\mu C_p = -\left(\frac{\partial H}{\partial P}\right)_T = \left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$$

CARNOT CYCLE

POWER: $\frac{W}{Q_2} = \frac{T_2 - T_1}{T_2}$ REFRIG: $\frac{W}{Q_1} = \frac{T_2 - T_1}{T_1}$



THERMODYNAMIC POTENTIALS

POTENTIAL	SYMBOL	MATHEMATICAL DEFINITIONS	INDEP'DT VARIABLES	DIFFERENTIAL EQUATIONS: BASIC	DIFFERENTIAL EQUATIONS: TRANSFORMED
RESIDUAL WORK (HELMHOLTZ FREE ENERGY)	A	$A = F - PV$ $A = E - TS$	V, T	$dA = -PdV - SdT$	
FREE ENERGY (GIBBS FREE ENERGY)	F	$F = A + PV$ $F = H - TS$	P, T	$dF = +VdP - SdT$	
INTERNAL ENERGY	E	$E = A + TS$ $E = H - PV$	V, T	$dE = -PdV + TdS$	$dE = C_v dT + \left[T\left(\frac{\partial P}{\partial T}\right)_V - P\right]dV$
ENTHALPY	H	$H = A + TS + PV$ $H = F + TS$ $H = E + PV$	P, T	$dH = +VdP + TdS$	$dH = C_p dT + \left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right]dP$

GENERALIZED THERMODYNAMIC EQUATIONS

REDUCED EQUATION OF STATE

$$\frac{V}{\alpha_c} = \frac{RT_c}{P_c\alpha_c}\frac{T_r}{P_r} - \alpha_r$$

SPECIFIC HEATS

$$\left(\frac{\partial C_p}{\partial P_r}\right)_{T_r} = \frac{P_c\alpha_c}{T_c}T_r\left(\frac{\partial^2\alpha_r}{\partial T_r^2}\right)_{P_r}$$

$$\frac{\Delta C_p}{K_2} = \int_0^{P_r}\left(\frac{\partial^2\alpha_r}{\partial T_r^2}\right)_{P_r}dP_r$$

$$C_p - C_v = -T\frac{\left[\frac{R}{P}\frac{\alpha_c}{T_c}\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}\right]^2}{\left[\frac{RT}{P^2} + \frac{\alpha_c}{T_c}\left(\frac{\partial\alpha_r}{\partial P_r}\right)_{T_r}\right]}$$

FUGACITY

$$-\frac{RT_c}{P_c\alpha_c} = \ln\frac{f}{P} = \frac{1}{T_r}\int_0^{P_r}\alpha_r\,dP_r$$

ENTHALPY

$$dH = C_p\,dT - P_c\alpha_c\left[\alpha_r - T_r\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}\right]dP_r$$

$$\frac{\Delta H}{K_3} = \int_0^{P_r}\left[\alpha_r - T_r\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}\right]dP_r$$

ENTROPY

$$dS = \frac{C_p}{T}dT - \frac{R}{P}dP + \frac{P_c\alpha_c}{T_c}\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}dP_r$$

$$S = C_p\ln T - R\ln P - \Delta S'$$

$$\frac{\Delta S'}{K_2} = \int_0^{P_r}\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}dP_r$$

This series of tables is based on the series of articles on "Hydrocarbon Thermodynamics" by Wayne C. Edmister as published in the March, April, and May, 1946, issues of *The Petroleum Engineer*.

Table 1 (above) summarizes the fundamental concepts of thermodynamics. It is expanded in Part 1 on page 79 of the March, 1946, issue of *The Petroleum Engineer*. Also, in W. C. Edmister's article in the *Journal of Chemistry*, Vol. 22, page 13.

Table 2 (center) summarizes and defines the laws of thermodynamics as applied to hydrocarbon fluids. Explanation and references are the same as for Table 1.

Table 3 (below) presents the equations that are used in computing enthalpies, entropies, and fugacities for hydrocarbons and their mixtures.

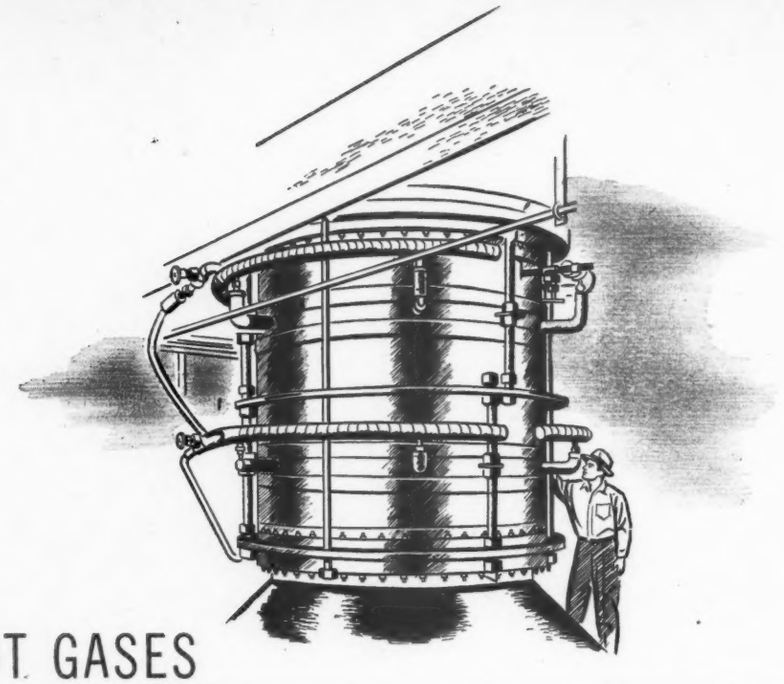
REFERENCES

Edmister, W. C., *The Petroleum Engineer*, March, 1946, page 79.

Edmister, W. C., *Ind. & Engr. Chem.*, 28, 1112 (1936); 30, 352 (1938); and 32, 373 (1940).

"Thermodynamic Properties of Methane."

"Thermodynamic Properties of Hydrocarbons," and "Specific Heat Ratios for Hydrocarbons."



RESISTS HOT GASES

Stainless steel unit operates at 1000° F.

Corrosive gases carrying pulverized catalyst rush through this huge expansion joint at more than 1000° Fahrenheit. For this severe service, design engineers looked for a metal that was strong and tough and had good resistance to heat, wear, and corrosion. They chose stainless steel. For stainless steel has a unique combination of properties which make it the one best metal for thousands of industrial and consumer uses, ranging all the way from food and chemical-processing equipment to streamlined trains and store fronts.

If you would like to keep informed of the newer uses of stainless and other alloy steels, ask to receive the monthly publication ELECTROMET REVIEW. Or, if you need advice on their production, properties, or fabrication, write our Technical Service Department. While we do not make steel—but manufacture the ferro-alloys used in its production—we have, through years of research and engineering, acquired a fund of information on the production, properties, and uses of alloy steels and irons.

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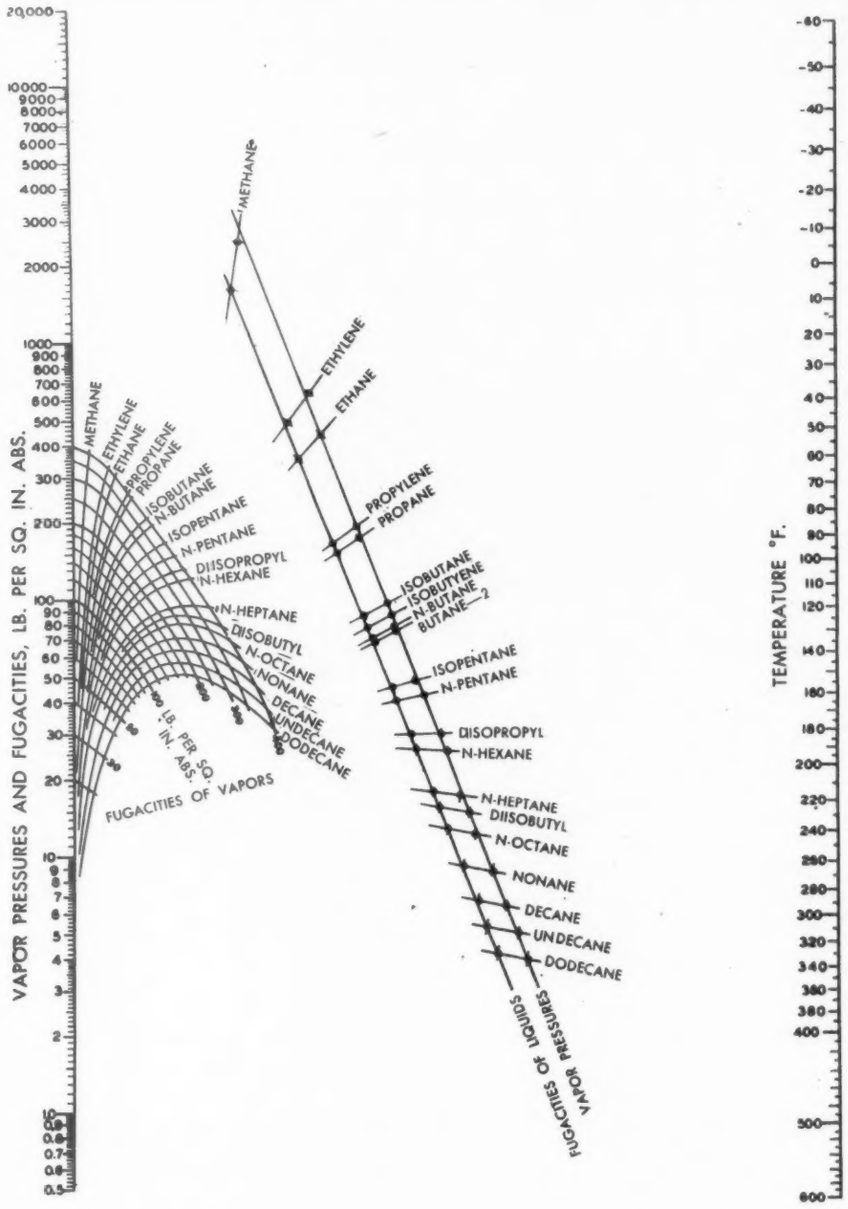
STAINLESS STEEL

BEAUTIFUL ENDURING STRONG TOUGH

BEST COMBINATION OF THESE QUALITIES

HYDROCARBON THERMODYNAMICS



This series of tables is based on the articles on "Hydrocarbon Thermodynamics," by Wayne C. Edmister, as published in the March, April, and May, 1946, issues of *The Petroleum Engineer*.

Fig. 1 (above) is a vapor pressure nomograph, using the Cox scales, with fugacities shown for purpose of comparison. The vapor pressure of the various hydrocarbons at various temperature can be determined on the left-hand scale by drawing a straight line or laying a straight-edge, through the temperature on the right-hand scale and the point on the diagonal "vapor pressures" line that corresponds to the hydrocarbon under consideration.

Example: What is the vapor pressure of n-butane at 100° F.?

Solution: A straight line from 100° F. on the right-hand scale through the n-butane point on the diagonal "vapor pressures" line intersects the left-hand scale at 52 lbs. per sq. in. abs., the vapor pressure of n-butane at that temperature. This would be equal to 37.6 lbs. per sq. in. gage pressure where the atmospheric pressure was 14.4 lbs. per sq. in.

REFERENCE

Gamson, B. W., Watson, K. M., et al, *National Petroleum News*, May 3, June 7, July 5, August 2, and September 6, 1944, "Vapor Pressures, Critical Properties, etc."

This Simple Compressor Meets the Complex Needs of a Changing Petroleum Industry

It's the Nash!

Here is a compressor presenting advantages found in no other device. Nash Compressors have only one moving part, rotating without metallic contact with the pump casing. No internal lubrication is required. Yet they produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure.

There are no valves, gears, pistons, sliding vanes, or other complicated wearing parts in a Nash. Compression is secured by an entirely different principle of operation. Because of this, gas pumping problems difficult with ordinary pumps are often easily handled by the Nash. For example, Nash Pumps are standard equipment in the Synthetic Rubber Industry, where they have met the needs of new and difficult processes.

Nash Compressors are compact and save space. They run without vibration, and compression is without pulsation. They maintain original performance over long periods. Service is assured by a nationwide net-work of Engineering Service offices. Instructive bulletin shows how they operate. Write for it.

One moving part.

No internal wearing parts.

No valves, pistons, or sliding vanes.

No internal lubrication.

Low maintenance.

Slugs of liquid entering pump do no harm.

Non-pulsating pressure.

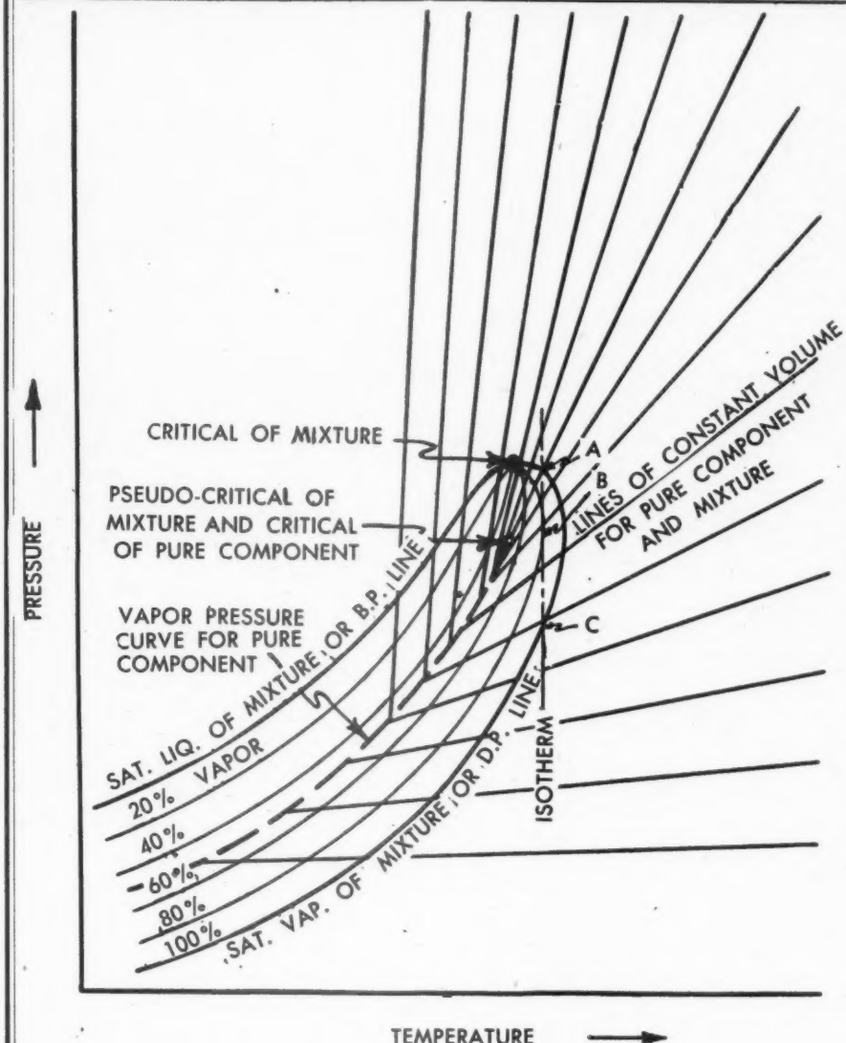
Saves floor space.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

272 WILSON, SO. NORWALK, CONN.

HYDROCARBON THERMODYNAMICS

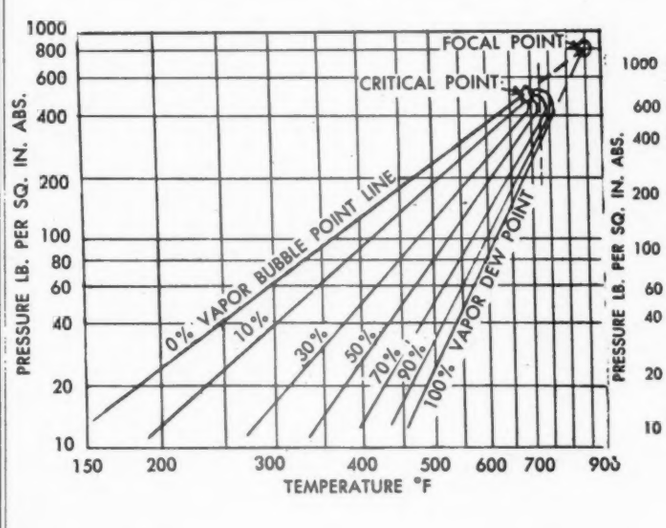


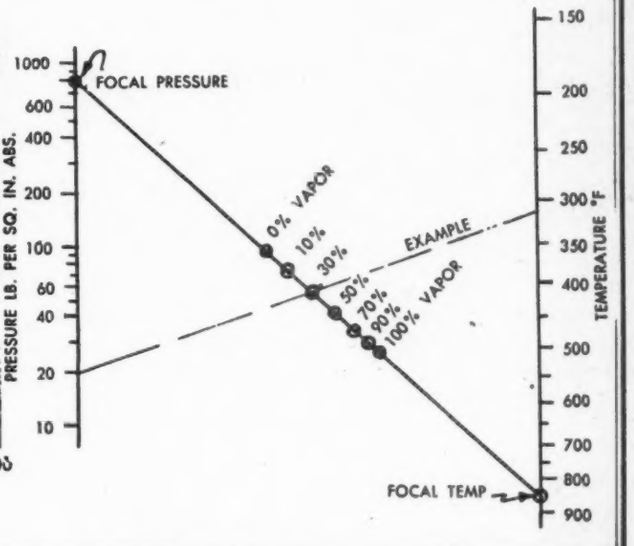
This series of tables is based on the articles on "Hydrocarbon Thermodynamics," by Wayne C. Edmister, as published in the March, April, and May, 1946, issues of *The Petroleum Engineer*.

Fig. 2 (left) is a pressure-temperature diagram of a pure component and a mixture of hydrocarbons illustrating the pseudocritical concept and retrograde phenomena. Note that the pressure vs. temperature plot for the mixture consists of two lines that join at the critical point. *Reference:* Kay, W. B., *Ind. & Eng. Chem.* Vol. 28, p. 1014 (1936), "Density of Hydrocarbon Gases and Vapors."

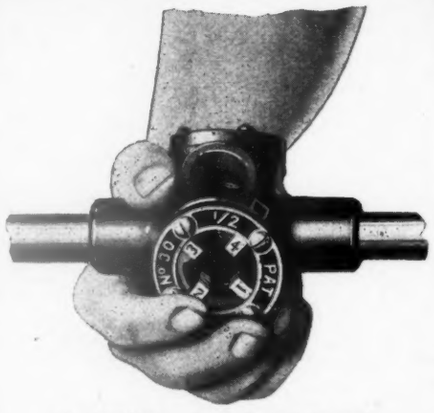
Fig. 3 (lower left) is a phase diagram of naphtha-kerosine plotted on log-log graph paper. *Reference:* Katz, D. L., and Brown, G. G., *Ind. & Eng. Chem.* Vol 29, p. 1408 (1937), "Vapor Pressure and Vaporization of Petroleum Fractions."

Fig. 4 (lower right) is a phase diagram of naphtha-kerosine plotted as an alignment chart.





GETS THE *OK* OF THE MAN ON THE JOB!



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Compactly designed—the Toledo 3-Way Threader is lightest, smallest and easiest to operate of all 3-way tools! No. 30 threads ⅜" to ¾" pipe, wt. 4-¾ lb. No. 31 threads ½" to 1" pipe, wt. 7 lb. Efficient...dependable.

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Sure he's smiling—the *right* pipe tools mean satisfaction all around!

Contractors and mechanics today can count on "smooth going" from start to finish—with easy-threading TOLEDO Pipe Tools on the job. These accurate, dependable tools are engineered to do a better job and help you *cut costs!* Preferred by experienced hands for nearly half a century.

In these busy days of building in residential, commercial and industrial fields . . . gear your pipe fitting to greater efficiency. Specify TOLEDO for unbeatable performance! The Toledo Pipe Threading Machine Company, Toledo, Ohio. New York Office, No. 2 Rector Street Building.

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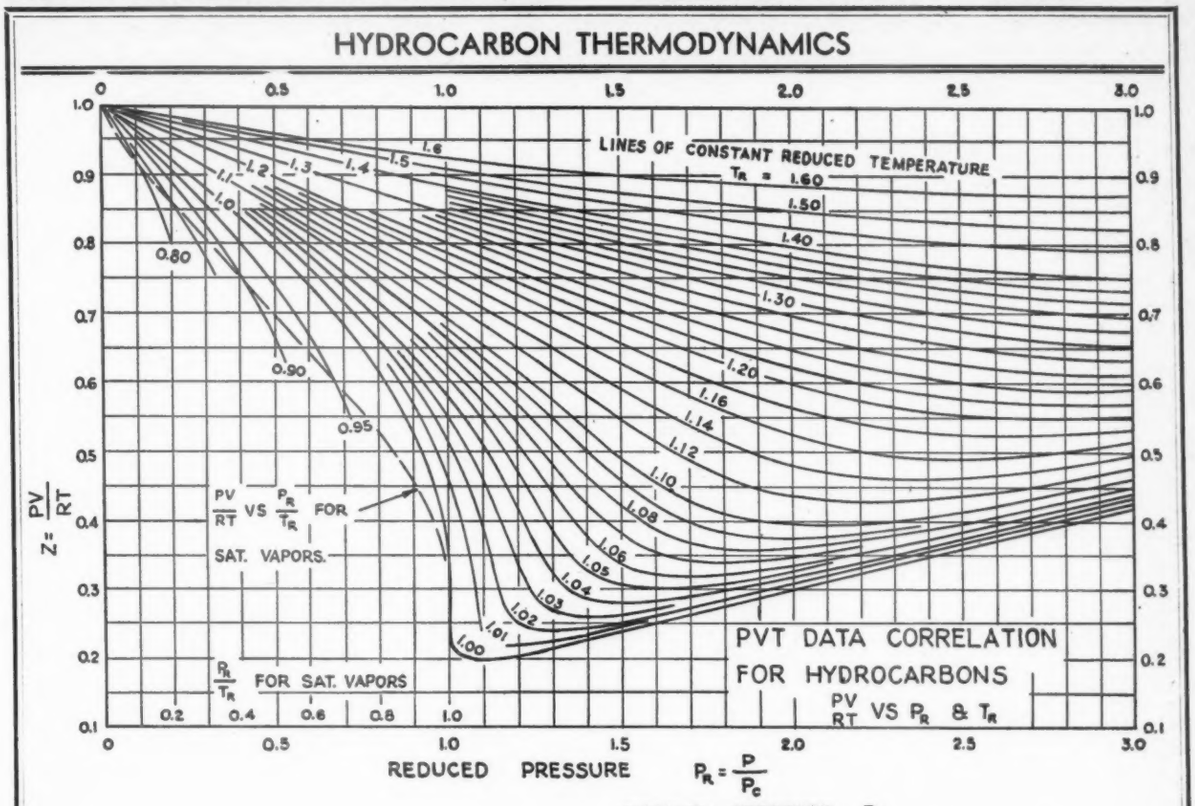
FOR PRECISION PIPE TOOLS



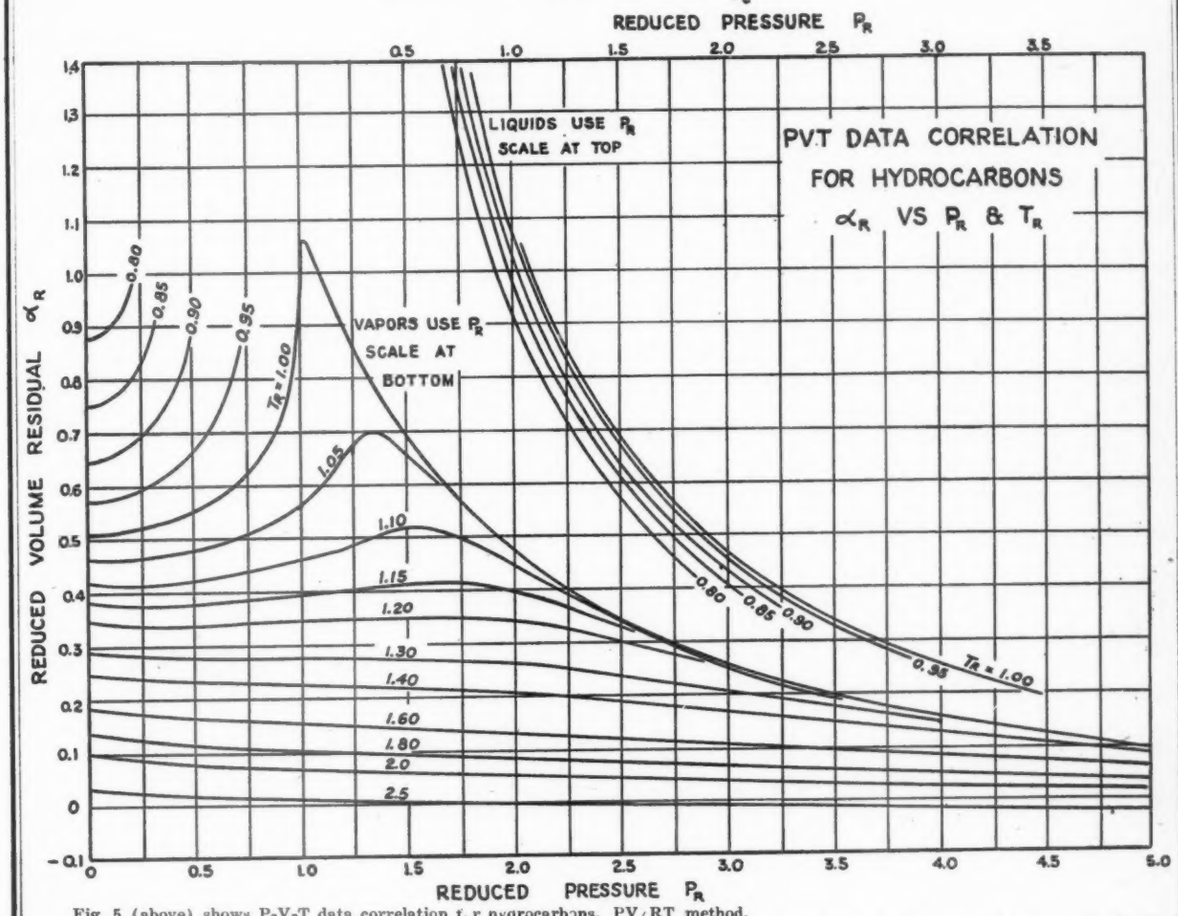


Fig. 5 (above) shows P-V-T data correlation for hydrocarbons, PV/RT method.
Fig. 6 (below) shows P-V-T data correlation for hydrocarbons, reduced residual volume method. *Reference:* Edmister, W. C., *The Petroleum Engineer*, March, 1936, p. 82.

Do You Need a High-Strength Alloy to Resist Corrosion?

One of these grades of HASTELLOY Alloy may be what you require

	HASTELLOY A	HASTELLOY B	HASTELLOY C	HASTELLOY D
Composition:	nickel-molybdenum-iron	nickel-molybdenum-iron	nickel-molybdenum-chromium-iron	nickel and silicon
Excellent Resistance To:	hydrochloric and sulphuric acid	boiling hydrochloric acid and wet hydrochloric acid gas	free chlorine, acid solutions of ferric and cupric salts, and sulphuric acid	sulphuric acid of all concentrations up to the boiling point
Good Resistance to:	phosphoric, acetic, formic, and other organic acids	sulphuric acid	hydrochloric and nitric acid	phosphoric acid
Available Forms:	castings, forgings hot-rolled bars, strip, plate, sheet, rods, wire, welded tubing	castings, forgings, hot-rolled bars, strip, plate sheet, rods, wire, welded tubing, cast or drawn welding rods	castings, plate, sheet, welded tubing, cast welding rods	castings, cast welding rods

Write us for samples and test them under your own operating conditions

Test coupons of these alloys are available without charge upon request . . . in sheet and cast form. In requesting samples, any information you can give us about the corrosive media, the type of equipment, or other conditions of service will help us choose the proper alloys to send to you.

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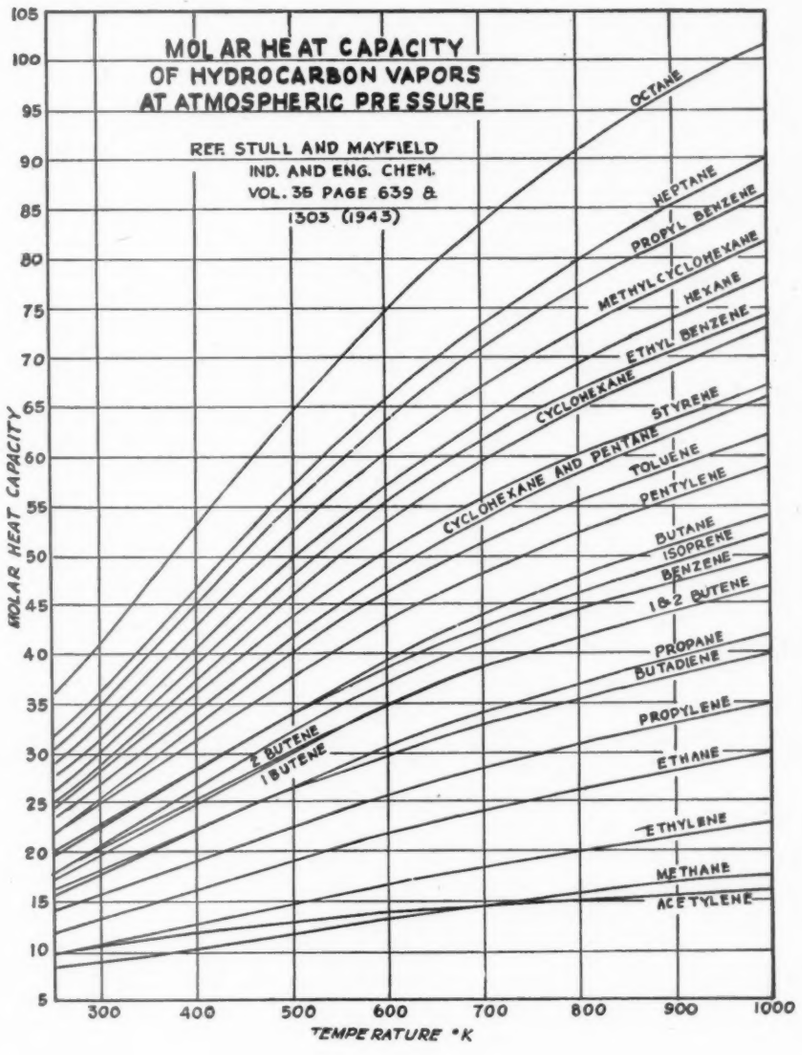

This series of tables is based on the articles on "Hydrocarbon Thermodynamics," by Wayne C. Edmister, as published in the March, April, and May, 1946, issues of *The Petroleum Engineer*.

Fig. 7 (above) shows the molar heat capacities of hydrocarbon vapors (B.t.u./°K./lb. mol.) at atmospheric pressure and at various temperatures. *Reference:* Stull, D. R., and Mayfield, F. D., *Ind. & Eng. Chem.* 35, 639 and 1303 (1945), "Heat Capacities of Hydrocarbon Gases."

Example: What is the heat capacity of 1 mol of butane at 800° K.?

Explanation: 800° Kelvin = 800° — 273° = 527°C. The Kelvin temperature scale is the absolute temperature scale for the Centigrade system of measurement.

Solution: Follow the 800° K. vertical line from the bottom of the chart to the intersection with the diagonal line marked "butane." The answer will be found opposite this intersection on the left-hand scale: Molar heat capacity of butane at 800° K. = 47.7 B.t.u.

FOR TUBING TO MATCH EACH CORROSIVE ATTACK

In the wide range of Croloy steel alloys developed by Babcock & Wilcox, there are types that make possible a close match between refinery tubing and the job conditions it must face.

The kind of corrosive attack to be resisted may be one of several types. Its primary cause may be high temperatures, in which case oxidation also must be specially guarded against. It may have its origin in contaminents or corrosive agents in the crude or gases being handled. Conditions encountered in processing may be its source, with the action of catalysts setting up reactions which tend to corrode or carburize tubing.

Among the Croloys listed in the panel and others in ferritic and austenitic stainless alloy steel types—covered by the B&W Croloy stainless steels—there are materials from which the one best tubing may be selected for each of your diverse refinery needs. Data on creep strength, tensile strength, and physical properties are available to complete the background for your decision.

Further help is also at your disposal. Through long associations with many branches of the petroleum industry, B&W engineers are well qualified to recommend the grade of tubing you need. When you call on Croloy, call on their advice and assistance.

CROLOY 1¼	CROLOY 2¼	CROLOY 3 M
Economic grade good creep strength properties. Somewhat more corrosion resistant than the chromium free steels.	*Exceptionally high creep strength* for polymerization and high pressure cracking. Otherwise similar in properties and characteristics to Croloy 2.	Somewhat better creep properties and better resistance to corrosion and oxidation than Croloy 2.
CROLOY 5	**CROLOY 7**	**CROLOY 9**
For operating conditions where corrosion resistance is primary requirement—provides good creep strength and oxidation resistance superior to Croloy 2.	Intermediate steel between Croloys 5 and 9 for operating conditions where corrosion resistance is the primary requirement. Somewhat more oxidation resistant than Croloy 5.	For severe operating conditions where high corrosion and oxidation resistance are essential—suitable for hydrogenation processes.
CROLOY 18-8S	**CROLOY 18-8S CB**	**CROLOY 25-20**
Practically unaffected by extremely corrosive oils at high temperatures. Has high creep strength and high resistance to oxidation.	Similar in properties to CROLOY 18-8S but stabilized with columbium, making it adaptable for welding or heating in carbide range.	For extreme resistance to oxidation and corrosion, for high-pressure, high-temperature services, as in hydrogenation, polymerization, and special heat-resisting installations.

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THE BABCOCK & WILCOX TUBE COMPANY
GENERAL OFFICES: BEAVER FALLS, PA.
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Running Tour WITH MEN IN THE INDUSTRY

• **Emil Geppelt, Jr.** and **C. F. Tears,** both of Dallas, Texas, have formed the Process Engineers, Inc., to serve the petroleum and chemical industries. This partnership is a culmination of 20 years' association, dating from the time when they were both connected with the Continental Oil Company.

Emil Geppelt, Jr.

C. F. Tears

Geppelt was associated with Continental from 1925-29, then was a consulting engineer until in 1938 he joined Mid-Continent Engineering Company, where he was president. Later he became vice president and general manager of the American Liberty Oil Company. During the war he was in charge of the design, construction, and operation of the firm's 100-octane gasoline plant at Texas City, Texas.

Tears, chemical engineer, was graduated from Cornell University in 1917. He has been engaged as a process engineer in the construction and operation of oil refining and chemical plants for 29 years and was associated with The Celanese Corporation of America for the last four years in connection with the synthetic chemical plant in Bishop, Texas.

• **N. Raymond Lamb,** for the last eight years in the geological and engineering departments of the Continental Oil Company, has joined the staff of the New Mexico Bureau of Mines and Mineral Resources as field petroleum engineer, with headquarters at Artesia.

• **Brad Mills** has been named executive vice president of the American Association of Oilwell Drilling Contractors, a newly created office. Mills has been executive secretary, which office is being discontinued. **J. Doyle Settle** has been named secretary of the association.

• **Gilbert P. Moore** and **T. G. Brown** have opened offices at 904 Continental Building, Dallas, Texas, under the firm name of Moore and Brown, to operate as consultants in the management, exploration, development, and appraisal of oil property.

• **W. R. Wheeler, Jr.,** formerly in the sales department of the American Iron and Machine Works Company, has resigned to accept a position as manager of the M-C-M Machine Works of Oklahoma City. Wheeler has been succeeded at the American Iron and Machine Works Company by **Elmer E. Rubac,** a former employe of American who has just been released from the Army.

• **Woodrow Dickson** has rejoined the Tretolite Company of California after two and a half years service with the Army Air Forces. Dickson is stationed in the Tretolite research laboratory at Los Angeles. **Carl Cooper** has also returned to the Tretolite Company after service with the Army Air Forces. He has resumed his duties with the research division of Tretolite at Los Angeles.

Irving Osborn is back in the field engineering department of the Tretolite Company of California after three years in the U. S. Army Paratroops. **Lyman Cralle** has returned to the Tretolite Company of California manufacturing department after three years service with the Army Air Forces.

• **Benjamin O'Shea** has retired as chairman of the board of directors of Union Carbide and Carbon Corporation. He will continue as a director and a member of the executive committee. The office of chairman of the board has been abolished with O'Shea's retirement.

At the organization meeting of the board of directors **Fred H. Haggerson** was re-elected president of the company, and all other officers were also re-elected.

• **Bowman Thomas,** chief production engineer for Humble Oil and Refining Company, delivered an address on petroleum engineering problems in the development and producing branches of the petroleum industry at a recent meeting of the Student Section of The American Institute of Mining and Metallurgical Engineers, University of Texas.

• **Walter H. "Tex" Ritterbusch, Jr.,** recently discharged from the Air Corps after three years' service as an aircraft engineering officer, has joined The S. M. Jones Company. Walter is the latest member of the field engineering staff organized by Jones to analyze wells, record sucker rod service, and confer and cooperate with production engineers to improve pumping conditions. With a B. S. in petroleum production engineering received at the University of Tulsa, Walter has also had practical field experience on seismograph crews and roustabouting for various oil companies.

W. H. Ritterbusch, Jr.

• **Ralph Wann** of Canon City, Colorado, was elected a director of the Colorado Fuel and Iron Corporation, Denver, Colorado, at a meeting of the board of directors April 17.

• **Paul C. White,** 38, vice president and chief engineer of the Commonwealth Gas Corporation died April 8 at Arlington, Virginia, Hospital. it was announced by the corporation's New York office.

• **P. E. Loye,** for several years a vice president and director of Reda Pump Company, Bartlesville, has announced his resignation, and his association with the recently formed Knowlton Engineering Company of Oklahoma City.

• **Hugh R. Lamberth** formerly with The Fluor Corporation, Ltd., in Los Angeles, and more recently in Mexico on special engineering work, is entering the employ of Joseph A. Coy Company, Inc., Tulsa, Oklahoma, as a special sales engineer.

• **Harry Leyendecker,** chief scout and statistician of Tide Water Associated Oil Company, has joined the executive staff of the oil and gas department of the City National Bank, Houston, Texas. Leyendecker, who served as a transportation official in the Petroleum Administration for War from February, 1942, until October, 1945, will be assistant to **George L. Nye,** vice president in charge of the bank's oil and gas department.

• **Homer W. Northrup,** formerly with the melting department of the Iron and Steel Foundry Division of the Crane Co. at Chicago and at its plant in Chattanooga, Tennessee, has recently joined the Chicago Technical Section of The International Nickel Company, Inc.

• **John H. Murrell** of the firm of DeGolyer and MacNaughton, Dallas, Texas, spoke to the Student Chapter of AIME, University of Texas, recently on oil developments in the Middle East.

J. R. Coleman, former instructor in the Department of Petroleum Engineering, University of Texas, and now chief engineer for Arctic Contractors, Fairbanks, Alaska, addressed the petroleum engineering classes recently on company operations in northern Alaska.

• **Edward J. Dudley** has been appointed public relations representative of the American Locomotive Company at Schenectady, New York. Prior to entering the Army in 1941, Dudley was a reporter for the *Rochester (N. Y.) Democrat and Chronicle* and had also worked on the staff of the *Rochester Journal-American.*

• **Joseph E. Bludworth** has been appointed director of petroleum chemicals research and development of Celanese Corporation of America.

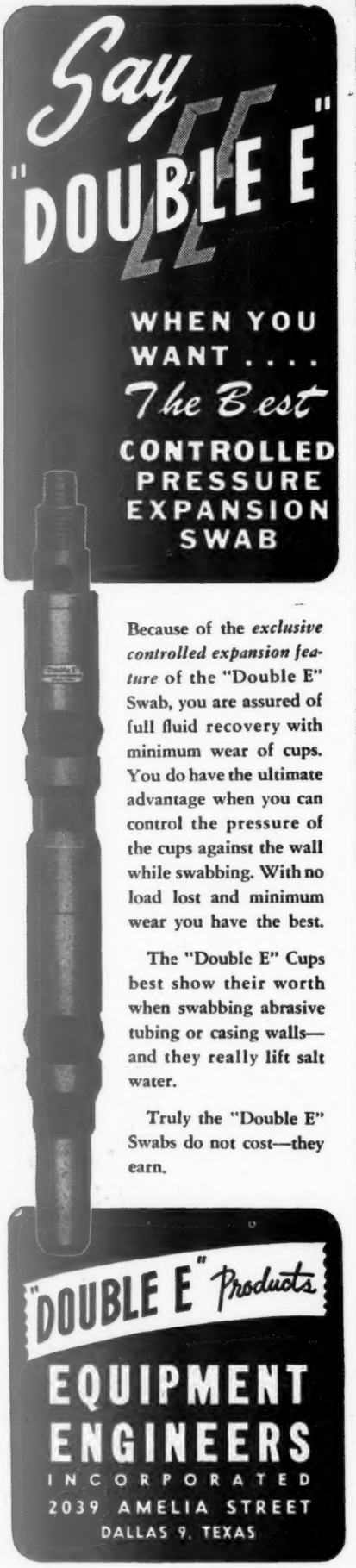
Kenneth D. Bowen has been appointed as plant manager of Celanese Corporation of America's chemical plant at Bishop, Texas.

• **Lt. General James H. Doolittle,** former commander-in-chief of the 8th Air Force and noted aviation expert, and **Dr. Jerome C. Hunsaker,** head of the department of mechanical and aeronautical engineering, Massachusetts Institute of Technology, were elected to the board of directors of the Shell Union Oil Corporation, at the annual meeting of stockholders at the firm's offices in the RCA Building, New York City. At the same meeting, the other members of the board were re-elected for the ensuing year.

Lt. Gen. J. H. Doolittle Dr. J. C. Hunsaker

With the exception of the war years, Doolittle has been connected with Shell since 1930, when he became manager of the aviation department of Shell Oil Company, Inc. He held this post until called to active service in 1940. Upon his return to civilian life, on January 5, 1946, he became vice president of Shell Union Oil Corporation.

Dr. Hunsaker has been head of the department of mechanical and aeronautical engineering, Massachusetts Institute of Technology, since 1933, and for five years prior to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The Best
CONTROLLED PRESSURE EXPANSION SWAB
Because of the *exclusive controlled expansion feature* of the "Double E" Swab, you are assured of full fluid recovery with minimum wear of cups. You do have the ultimate advantage when you can control the pressure of the cups against the wall while swabbing. With no load lost and minimum wear you have the best.
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that time, was vice president of the Goodyear-Zeppelin Corporation. From 1926-1928, he was assistant vice president of the Bell Telephone Laboratories.

• **W. C. Lane** has been appointed assistant manager of Standard of California's foreign trade department. He has served as president of the California Commercial Company, a Standard subsidiary. from 1941 to 194. and since his discharge from the Navy last December. During the war Lane rose to the rank of lieutenant commander, and at the time of his discharge was stationed in London. He joined Standard's staff in Seattle in 1926. In 1937 he was made assistant to the manager of the New York office, a position he held until the formation of the California Commercial Company in 1940, when he became a vice president of the new company. He was elected president of that company in 1941.

W. C. Lane

• **Colonel James E. McNary,** specialist of Standard Oil Company (New Jersey) received the Exceptional Civilian Service Award from the Army Service Forces as a special advisor to the Quartermaster General for his work in introducing and developing the first portable pipe lines in the North African campaign, special heavy drums for handling gasoline in exposed areas, and for developing a field fueling device that was used for planes, tanks and combat vehicles.

• **Harold O. Laffitte** of Roselle Park, New Jersey, an engineering supervisor in the Esso tanker fleet, won an award for exceptional service in expediting the unloading of tankers in invasion ports.

• **James H. Withers** has been appointed district manager in charge of the San Francisco and Los Angeles offices of Tube Turns, Inc. He will divide his time equally between the San Francisco office, at 2611-12 Russ Building, and the Los Angeles office, at 1625 South Hill Street.

• **S. M. (Skid) Spears, Jr.,** has been promoted to assistant district manager of the New York office of Tube Turns, Inc.

• **Robert B. Curran,** manager of the Carter's Northwest Division, has been named a director of the company. One of the youngest Carter employes in a major executive post, Curran, 37, has made a rapid rise in the oil industry, and his election to the board of directors is a tribute to his ability and past achievements.

• **D. A. Sutch** has been appointed general superintendent of Wickwire Spencer Steel's Clinton plant. Sutch, who has been works manager of the Wickwire Spencer Aviation Corporation, Newark, New Jersey, subsidiary of The Colorado Fuel and Iron Corporation, succeeds **G. G. Lloyd,** who was recently transferred to the Buffalo plant as general superintendent.

• **W. C. Stevenson,** formerly manager of the Oleum Refinery, has been appointed assistant to the executive vice president in charge of industrial relations of Union Oil Company of California. Stevenson assumes the position held by **H. B. Dean,** recently retired from the company. **George Hemmen** has been appointed manager of the Oleum Refinery.

After completing 28 years' service with Union Oil Company of California, **S. H. Grinnell,** superintendent of service and maintenance, has left the company to accept a position as manager of operations for Pacific Airmotive Corporation. **H. E. Giles** assumes the position formerly held by Grinnell.

• **Earl B. Noble,** manager of exploration of the Union Oil Company, was elected president of the American Association of Petroleum Geologists at the annual meeting. Noble succeeds **Monroe G. Cairney** as president. Serving with Noble as officers of the association will be **David P. Olcott** of Humble Oil and Refining Company, newly elected vice president, and **Edward A. Koester** of Darby Petroleum Corporation, as secretary-treasurer.

• **Dan K. Heiple** has rejoined R. G. LeTourneau, Inc., Peoria, Illinois, as a field engineer in the installation department. Since early in 1942 he served as officer in charge of service and maintenance of aircraft with the United States Navy.

• **Claude A. Gates,** New York City, manager of Zone 1, was appointed vice president of the Wheelco Instrument Company; **C. H. Joy,** Cleveland, manager of Zone 2 and at present a director was appointed vice president; **R. A. Schoenfeld,** Chicago, manager of Zone 3 and at present a vice president was named a director of the company, and **Chas. L. Saunders,** vice president was appointed to the office of executive vice president. Saunders has his headquarters in the main office and plant at 847 West Harrison Street, Chicago.

• **Bruce H. Beesley** has been named sales and service engineer for the Eastman Oil Well Survey Company in the northern and eastern Texas area. Beesley held a similar position in the Oklahoma area prior to entering the Army. His headquarters will be in Dallas.

• **Daniel J. Killfoile,** recently released from the signal corps in which he served for three years, is now on the sales staff of Alloy Steel Products Company, Linden, New Jersey.

• **Jack S. Smith,** manager of the cementing department of International Cementers, Inc., made an extended tour of various oil producing areas of South America. Plans included stays in Maracaibo, Eastern Venezuela; Baranquilla, Cucuta, and Bogota, Colombia; and via the Canal Zone to Mexico, he returned early in May.

• **Dr. J. Mitchel Fain,** lately a colonel with the Army Air Forces, has rejoined the staff of Foster D. Snell, Inc., consulting chemists and engineers, Brooklyn, New York, as account executive in charge of technical development for a group of manufacturers of chemical specialties.

• **Cornell E. Jones,** formerly a major in the army corps of engineers, has been named sales development manager of the Caterpillar Tractor Company, Peoria, Illinois. Jones is well known in the heavy machinery and contractors' industry, having served with county and state highway departments, the J. D. Adams Company, and International Harvester Company both in domestic and foreign operations. Jones takes over the duties of **Kenneth F. Park,** recently named to the newly created post of engineering consultant on all matters pertaining to the earthmoving field.

Cornell E. Jones

• **William P. Loyzelle** has been appointed as traffic manager for all divisions except the Railway Steel Spring Division of American Locomotive Company. Loyzelle's headquarters will be in Schenectady, New

York. The appointment became effective upon the retirement on February 1 of **W. J. Hall,** traffic manager, who had been associated with Alco since June 1, 1911. **Benjamin Davis** will continue as traffic manager of the Railway Steel Spring Division with headquarters in New York City.

• **Stephen C. May** has joined The Pacific Manufacturing Corporation, Cleveland, Ohio, as vice president and general sales manager. He was employed as general sales manager of the Darling Valve and Manufacturing Company from 1940 to 1944 at which time he became vice president and general sales manager. During 1939 he was affiliated with G. S. Blakeslee and Company, Inc., Cicero, Illinois. During the 12 year period from 1927 to 1939 he was affiliated with The Iron Fireman Manufacturing Company, Cleveland.

• **F. A. Leovy** vice chairman of Gulf Oil Corporation, retired May 1 after 42 years' service with the Gulf companies. When Leovy began his activities with Gulf at Beaumont, Texas, in 1904 the company was a small producing, refining, and transportation concern in Texas and Oklahoma.

F. A. Leovy

Leovy's list of titles with Gulf Oil Corporation and its subsidiaries include: Vice chairman of the board, a director and a member of the executive committee, finance committee and annuity committee of the Gulf Oil Corporation, a director and chairman of the board of Gulf Refining Company, and a director and president of Mexican Gulf Oil Company, Western Gulf Oil Company, Venezuela Gulf Oil Company, Gulf Exploration Company, Gulf Research and Development Company, American International Fuel and Petroleum Company, Caribbean Gulf Oil Company Colombian Gulf Oil Company, Darien Gulf Oil Company, and Magdalena Gulf Oil Company.

• **A. E. (Bud) Harris, Jr.,** former flight engineer, recently released from U. S. Air Force, has joined Oil Base Incorporated as representative and consultant.

• **W. S. (Bill) Everett,** former lieutenant commander in the Office of Inspector of Naval Materiel, has been appointed sales engineer of Enterprise Engine and Foundry Company.

• **Gilbert A. Parks** has been appointed assistant division engineer of the Rocky Mountain Division, of Core Laboratories, Inc. Parks will make his headquarters in either Casper, Wyoming, or Denver, Colorado.

William E. Stiles has been appointed division engineer of the North and West Texas, Oklahoma, and Kansas Divisions, of Core Laboratories, Inc., with headquarters in Dallas, Texas.

• **H. Cubbie Roane** has been named assistant district manager of the Atlanta office of Bowser, Inc. He is a graduate in electrical engineering of Louisiana State University, and for the last 12 years has been with the Gulf Oil Corporation.

• **Lieutenant Commander Robert J. Bradley** has joined DeGolyer and MacNaughton, Dallas, Texas. Until recently he has been on duty in the Secretary of Navy's office in Washington. Prior to his war service, Bradley was an economist with California Standard and affiliates, serving in San Francisco, California, and the Middle East.

don't fool

around with Oil or Gasoline Fires

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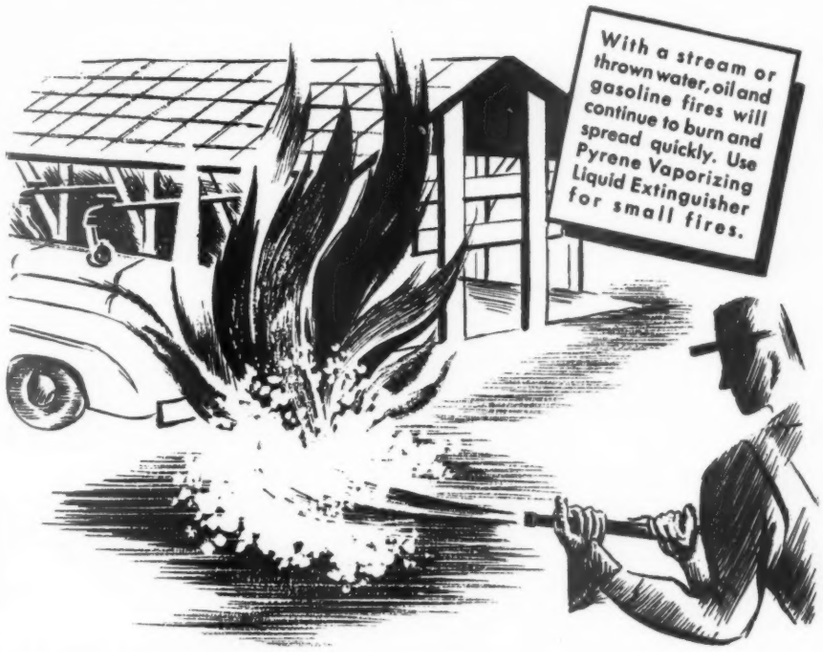
With a stream or thrown water, oil and gasoline fires will continue to burn and spread quickly. Use Pyrene Vaporizing Liquid Extinguisher for small fires.

PYRENE PLAYPIPE AND FOAM FOR LARGER SPILL FIRES

Pyrene Foam kills large oil and gasoline fires quickly because it was specifically designed and developed for these difficult fires. Pyrene Foam used with the Playpipe puts flames and heat down fast. The smothering action of the foam kills the fire. It's easy to use. Plain hydrant water — fresh or salt — and foam mixed at the nozzle of the Playpipe is a one-man operation. The extinguishing action is fast and adjacent fires may be put out with plain water with the simple action of shutting off foam supply.

PYRENE FOAM SYSTEMS FOR TANK FIRES

For larger fires, foam makers in a variety of capacities are engineered to meet specific hazards. Pyrene Proportioning Tanks feed Foam Compound into high pressure water lines through an inductor. Pyrene Foam is produced at Foam maker installed at base of Foam riser. Write for AIR FOAM, a booklet describing Pyrene Playpipes and Systems.

Pyrene Manufacturing Company
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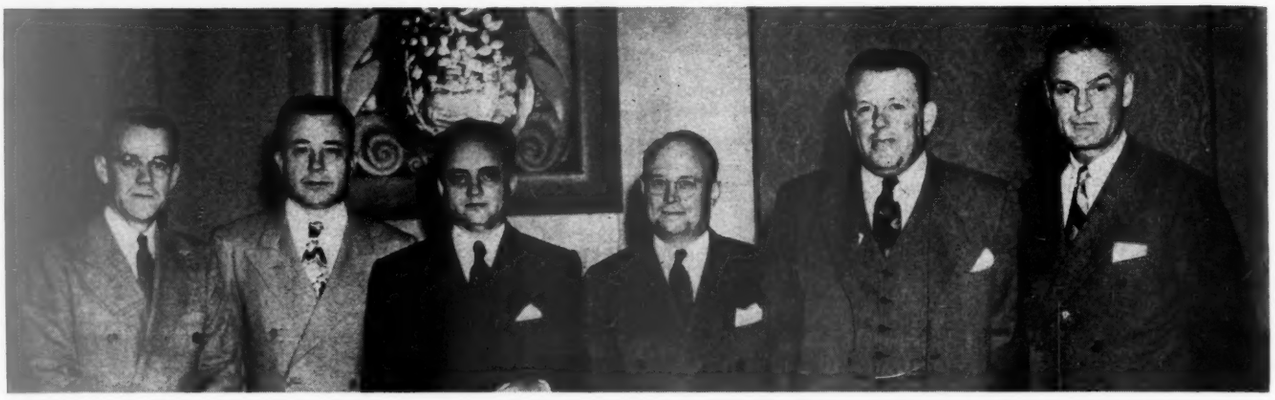
Affiliated with the C-O-Two Fire Equipment Co.

Natural Gasoline Association of America re-elects officers



At the recent Silver Anniversary meeting of the Natural Gasoline Association of America all incumbent officers were re-elected for 1946. Left to right: W. F. Lowe, secretary-treasurer; C. R. Williams, vice president; P. M. Raigorodsky, vice president; J. H. Dunn, president; J. B. Atkins, vice president, and R. D. Gibbs, vice president.

Marion's new name

Announcement is made by M. E. Montrose, president, of the change in name from the Marion Steam Shovel Company to Marion Power Shovel Company after stockholder approval at the annual meeting held in Marion, Ohio, recently. All directors were reelected.

This change in name, the first since the company was founded more than 60 years ago, was desirable because the larger portion of production during the last 15 years has been diesel, gasoline, and electric-powered machines and the new name more truly identifies the company with its products, the announcement said.

Wimmer resigns

The resignation of A. C. Wimmer, treasurer of Oil Well Supply Company, United States Steel subsidiary, after 30 years' association with the company, was announced at Dallas, Texas, by Fred F. Murray, president. Wimmer was succeeded by G. F. Goetzinger, assistant treasurer, effective May 1.

Wimmer joined the "Oilwell" organization in 1916 and his association with the company has been interrupted only by his active service with the 358th Infantry, 90th Division in World War I.

Goetzinger has been with "Oilwell" 32 years, having begun as a stenographer in the Pittsburgh office in 1914. He became a credit clerk in a short time and has been continuously associated with credit responsibilities except for two years after his return from World War I, when he was secretary to Louis Brown, then president of the company. He served as credit manager in the eastern division for 12 years and since April, 1944, has been at the company's headquarters office in Dallas as assistant treasurer and general credit manager.

New Manhattan distributor

Appointment of The Republic Supply Company of California as distributor of Manhattan industrial rubber products, has been announced by Raybestos-Manhattan, Inc., Manhattan Rubber Division, Passaic.

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...And that's the way we like 'em. We wouldn't want you to recommend to the boss that he buy JENSENS unless you thought they were best—considering initial cost, operating cost, depreciation, design and choice of materials.

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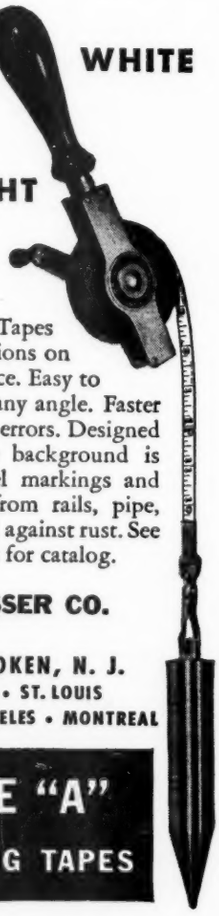

WYTEFACE "A" Steel Tapes have *raised* black graduations on a crack-proof white surface. Easy to read in any light, from any angle. Faster measurements with fewer errors. Designed for hard service. White background is protected by raised steel markings and rims. Resists abrasion from rails, pipe, rocks, concrete. Protected against rust. See your supply house. Write for catalog.

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Drafting Reproduction Surveying Equipment and Materials Slide Rules Measuring Tapes

LAUGH WITH BARNEY

A Negro defendant in Corporation Court at Dallas, Texas, told Judge Joe Hill he felt that the two charges against him, fighting and disturbing the peace, were unfounded.

"In the first place, Judge," he explained. "There wasn't no fight. My girl friend was beating me up. And Judge, this was down at Elm and Central on Saturday night. There wasn't no peace to be disturbed."

* * *

A kiss is a peculiar proposition of no use to one, yet absolute bliss to two. The small boy gets it for nothing, the young man has to steal it and the old man has to buy it. The baby's right, the lover's privilege, the hypocrite's mask. To a young girl, faith; to a married woman, hope, and to an old maid, charity.

* * *

A bathing beauty is a girl who has a wonderful profile all the way down.

* * *

A construction foreman working for a large building company had the record of doing jobs twice as fast as anyone else, and also of being a crank. One day he noticed a fellow running a wheelbarrow and thought he wasn't going fast enough. Curtly he told the man to snap it up and go faster. The workman answered: "Aw, what's the hurry? Rome wasn't built in a day."

The foreman's reply was heated: "No, but I wasn't foreman on that job, either!"

* * *

Doctor: You've got acute appendicitis.
Model: Cut that stuff. I came here to be examined, not admired."

* * *

I want a husband like an ostrich . . . they can see very little and can digest anything.

* * *

"I want you to have a good time at the party, Marion, dear, but I want you to be a good girl." "Make up your mind, mother," said Marion.

* * *

"All right now, rookie, what is maneuver?" "That's what you put on grass, sir, to make it grow."

* * *

It's tough to find
For love or money,
A joke that's clean
And also funny.

* * *

The automobile motor pounded and suddenly wheezed to a stop on a lonely road.

"I wonder," mused the sailor, "what that knock is?"

"Maybe," suggested his blonde companion, "it's opportunity!"

* * *

A meddling old woman accused one of the contractor's workmen of having reverted to drink because "with her own eyes," she had seen his wheelbarrow standing outside the tavern.

The accused man made no verbal defense, but that evening he placed his wheelbarrow outside her door and left it there all night.

* * *

"Was the baby sent down from heaven, Mama?"

"Yes, dear."

"They like to have it nice and quiet up there, don't they?"

* * *

A modest girl never pursues a man.
Nor does a mousetrap pursue a mouse.

Girl Friend: I'm getting so thin you can count my ribs."

Boy Friend: Gee! Thanks!

* * *

An American soldier stationed in Japan wrote the following letter to Washington: "I've been thinking about the present system for demobilizing Army men. It seems to me the best way this could be handled would be to discharge all soldiers alphabetically."

(Signed)
PFC. JAMES M. ADAMS.

* * *

A man visiting a household for the first time found that the chief occupant of the home was a very wild little boy.

This little lad spent most of his time driving nails into all the expensive furniture.

The bewildered guest eyed the youngster, then he turned to his host, "I beg your pardon, Jim," he exclaimed, "don't you find it rather expensive to let your little boy do that?"

"Not at all," replied the father. "I get the nails wholesale."

* * *

They hired a male swimming star to appear opposite Esther Williams in a big splashy Hollywood picture. He beat a hasty crawl to Hollywood and the first day on the set, he was told by the director to climb to the 35-foot board and dive into the pool for a special shot.

Up the ladder to the board skittered the young natator. Suddenly he was heard to yell: "Hey! I can't dive—there's no water in the pool!"

The director turned bored eyes up to the figure high on the board. "How do you like that?" he sneered contemptuously to his stooges. "Five minutes on the set and he gets temperamental!"

* * *

A lawyer was walking down Broadway the other day when he ran into an old friend, whom he'd recently given some simple legal advice, and whom he'd presented with a pretty big bill.

"Nice day, isn't it?" cried the friend, and then added hastily: "Remember, I'm not asking you; I'm telling you."

* * *

"Herbert," said the young lady, "you shouldn't kiss me with all this crowd standing around."

"I didn't kiss you," replied Herbert, "and if I catch that guy, I'll teach him a thing or two!"

"Don't bother," she sighed, "you couldn't teach him anything."

* * *

Two great big rough pianomovers rang Merton Mildewed's doorbell. "Hey, bud, you order a pianner from the Tinwhistle Piano Company?" one of them rasped.

Merton shook his head. "Not a piano," he said nervously, "I ordered a flute."

The piano mover looked menacingly at a piece of paper. "It says here it was a pianner—bud."

Merton studied the sweating huskies steadily.

"Very well," he stuttered, "bring it in. But if your company makes any more mistakes like that, I'll have to deal somewhere else."

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A Can Unique

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The "Can-Do"

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It's not the can that counts, but what's inside it. Put the contents in the can of

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Compact Research and Coordinating Committee

Members of the Research and Coordinating Committee of the Interstate Compact Commission, taken at meeting in Tulsa, Oklahoma, recently. Left to right: Lloyd Jordan, El Dorado, Arkansas; S. F. Peterson, Springfield, Illinois; L. B. Taylor, Wichita, Kansas; Howard Hinson, Amarillo, Texas; Ludwig Schmidt, Bartlesville, Oklahoma; Kork Kelley, Wichita Falls, Texas; D. J. Jones, Lexington, Kentucky; Walter T. Pound, chairman, Oklahoma City, Oklahoma; Dr. E. T. Heck, Albany, New York; H. B. Burwell, Nashville, Tennessee; W. Roy MacGinnis, Denver, Colorado; A. H. Barbeck, Austin, Texas; Jack Baumel, Austin, and R. R. Spurrier, Santa Fe, New Mexico.

Houston division manager

Wm. C. "Casey" Jones, after a year and a half in the contracting business in Texas, has rejoined the sales staff of Security Engineering Company, Inc., as district manager of the Houston division with offices at 1053 Mellie Esperson Building, Houston, Texas.

"Casey" has a thorough knowledge of the company's products and operators' requirements gained from previous experience on Security's sales staff. After working California from both the Whittier and Bakersfield offices, he was transferred to Texas, where he covered the fields of South Texas, East Texas, and Louisiana.

Eastern regional manager

Richard F. Garretson was recently appointed eastern regional manager of Ransome Machinery Company, Industrial Division, a subsidiary of Worthington Pump and Machinery Corporation. He is in charge of sales of welding and work positioning equipment with offices at 2905 North Broad Street, Philadelphia, Pennsylvania.

Garretson joined Ransome in 1936 and is a pioneer in promoting positioning equipment.

Calif. companies merge

E. S. Dulin, president of Byron Jackson Company, and J. C. Ballagh, president of Patterson-Ballagh Corporation, jointly announce the acquisition by Byron Jackson Company of all of the outstanding stock of the Patterson-Ballagh Corporation.

Patterson-Ballagh will operate as a separate division of Byron Jackson Company, which company has owned a minority interest in Patterson-Ballagh since its formation and which has been working in close harmony with that firm through the presence of Dulin on its board of directors.

Both Byron Jackson Company and Patterson-Ballagh are unusually well known throughout the oil industry and their products are used in every operating oil field of the world. Patterson-Ballagh is mainly concerned with the fabrication of important rubber specialties along with certain other products non-competitive with those of Byron Jackson Company.

The merger of these companies will supplement the efforts of each and, coupled with the expansion programs now planned for domestic and foreign operations of both the oil tool and pump divisions of Byron Jackson Company, comes at a very opportune time.

Patterson-Ballagh Corporation is one of the pioneers in the oil tool industry, being founded in 1927 and introducing rubber casing and drill pipe protectors. Since then many additions to the line of products have been made and are being contemplated, including the wire line guide, pipe wiper, swivel and traveling block bumpers, and the mud gun. In development are many items for producing wells, including a deep well swab, sucker rod wipers, and wire line wipers.

No immediate changes in management, personnel, or sales distribution are being contemplated. The manufacture, sales, and distribution of Patterson-Ballagh items will remain under the Patterson-Ballagh name.

J. C. Ballagh will continue as president and general manager of the firm. D. G. Miller continues as secretary. He has been associated with Patterson-Ballagh many years and is the inventor and designer of many of their most important items, as well as being a pioneer in the turbine pump industry.

Republic Supply opens new Houston building

Republic Supply Company announces the completion of the first unit of its new supply store and warehouse at 501 North Greenwood Avenue, Houston, Texas. According to A. B. Judd, vice president and general manager, the company is now prepared to provide what is believed to be the "last word in modern oil industry supply service."

The new store and warehouse is of all steel construction 142 ft. by 160 ft. with main floor and balcony providing more than 37,000 sq. ft. of space. The building, situated on a 14-acre tract owned by the company in the Esperson industrial section, will be enlarged further by the addition of a second unit 75 ft. by 300 ft. now being designed. This second unit will be crane equipped to handle tubular goods and heavy machinery.

Republic Supply Company was organized at Beaumont in 1910 and shortly afterward moved its general headquarters to Houston. Since that time the company has expanded with the growth of the oil industry until today it maintains 45 sales and service points throughout the following important oil producing states: Arkansas, Illinois, Indiana, Kansas, Louisiana, Mississippi, New Mexico, Oklahoma, and Texas.

Republic Supply Company is a wholly owned subsidiary of the Republic Steel Corporation of Cleveland.

In addition to the 1200 oil men and oil equipment manufacturers from all parts of the country attending the formal opening of Republic's new supply store and warehouse April 27, were the following officials of the Republic Steel Corporation from Cleveland, Ohio: C. M. White, president; N. J. Clarke, senior vice president of Republic Steel Corporation and president of Republic Supply Company; E. M. Richards, vice president in charge of operations; J. M. Schlendorf, vice president in charge of sales; W. W. Hancock, vice president, secretary and treasurer; P. F. Boyer, vice president and comptroller; W. M. Kelley, assistant to vice president in charge of operations, and Manly B. Brown, manager of sales, pipe division.

Interior view of a part of the new building.

PROTECT YOURSELF AGAINST BROKEN BOLTS

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PRECISION BOLTS

There's less danger of breakage since Standco bolts are machined after heat treating. This prevents internal stress concentration at thread roots.

The highest quality materials used in Standco bolts have plenty of strength and temperature resistance to resist breakage under severe conditions.

Standard lengths of Standco bolts are ready for immediate shipment out of stock. Special lengths can usually be shipped within 48 hours. Be sure Standco Precision Bolts are used on your next job.

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Lincoln foundation awards

An exceptional opportunity for those engaged in the design, manufacture, or construction of any type of petroleum machinery or parts, is offered by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in the announcement of its new $200,000 "Design-for-Progress" Award Program.

"Petroleum Machinery" is admitted as one division of the "Industry Machinery" classification and includes any type of machinery used in the petroleum industry. Those familiar with the petroleum industry may also enter the competition under the program's "Containers" or "Maintenance" classifications, each of which offers a total of $5800 in classificational awards.

Four awards totalling $1600, established for the petroleum division of the industry machinery classification are:

	1st	2nd	3rd	4th
Division	$700	$500	$250	$150

Papers in the petroleum machinery division are also eligible for the industry machinery classificational awards of:

	1st	2nd	3rd	4th
Classification	$2500	$1500	$1000	$800

Three winners of divisional and classificational awards will also be possible recipients of the main program awards of $10,000, $7,500, and $5,000, respectively. The principal program award, which may be won by a paper in the industry machinery classification, is $13,200.

An author entering his paper in the above division of the industry machinery classification, not winning any other award, may still win one of the 217 honorable mention awards of $100 each.

Complete details of The $200,000 "Design-for-Progress" Award Program, which closes June 1, 1947, may be obtained by writing the Secretary, The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio.

Heads Stanolind Pipe Line

F. O. Prior has announced his resignation from the position of president of Stanolind Pipe Line Company, and the election of B. C. Clardy as president of the company and member of the board of directors. Prior will retain his present position as chairman of the board of directors.

B. C. Clardy

Clardy has taken over his official duties with Stanolind Pipe Line Company and resides in Tulsa, Oklahoma. Stanolind Pipe Line Company is the pipe line operating subsidiary of Standard Oil Company (Indiana).

Watson retires

Boyd Watson, district manager of the New York office of the Spang-Chalfant Division of the National Supply Company, retired May 1 after 41 years with the division and its predecessor, Spang Chalfant, Inc. W. J. Stanton, who has been with the company for 14 years, succeeds Watson. Stanton was the company's liaison representative in Washington from 1941 throughout the war.

W. J. Stanton

Watson, who is well-known in jobbing circles and in the pipe and oil industry, first served Spang Chalfant in the legal department. He later transferred to the sales organization as district manager in the Pittsburgh office and later as vice president of Spang Chalfant, Inc., with offices in New York.

Stanton, during his many years in the pipe industry, has developed a host of friends in the public utility, municipal, and transportation fields. Prior to joining the Spang-Chalfant organization, he spent 17 years with General Electric Company.

Flanders to Lane-Wells

George S. Flanders, widely known in oil tool export circles, has joined Lane-Wells Company as export sales engineer, according to an announcement made by James D. Hughes, Lane-Wells sales manager.

Flanders was active in oil tool export work before the war and had headquarters in Trinidad and New York City. During the war he was stationed in England where he worked on the planning and construction of military pipe line systems for the invasion of the continent.

Flanders in his new capacity will make his headquarters in Los Angeles and make periodic trips through foreign fields to service Lane-Wells equipment and represent the company abroad.

Underground Warfare

IS STILL GOING ON

REILLY ENAMEL FIGHTS CORROSION

● There is no peace for unprotected pipe lines. From the minute such a line goes into the ground it must fight for its life. Moisture, gaseous vapors, soil acids and alkalies, electrolysis—are the corrosive agencies that make the attack.

The best protection you can give steel pipe against these underground enemies is a coating of hard, tough Reilly Enamel. This coal tar coating seals the steel against all corrosive agencies, and insulates it against extraneous materials and elements. Reilly Enamel is so regulated in its properties that it will withstand temperatures as high as 160° F. without flow or sag—and as low as minus 20° F. without cracking or checking.

Pipe lines coated with Reilly Enamel are exceptionally free from costly service interruptions, and can be depended upon for long life and low maintenance costs. Made in two standard grades, or to specification.

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This 20-page booklet describes Reilly Enamel and other Reilly Protective Coatings for metal, cement, brick and wood surfaces. Write for your copy today.

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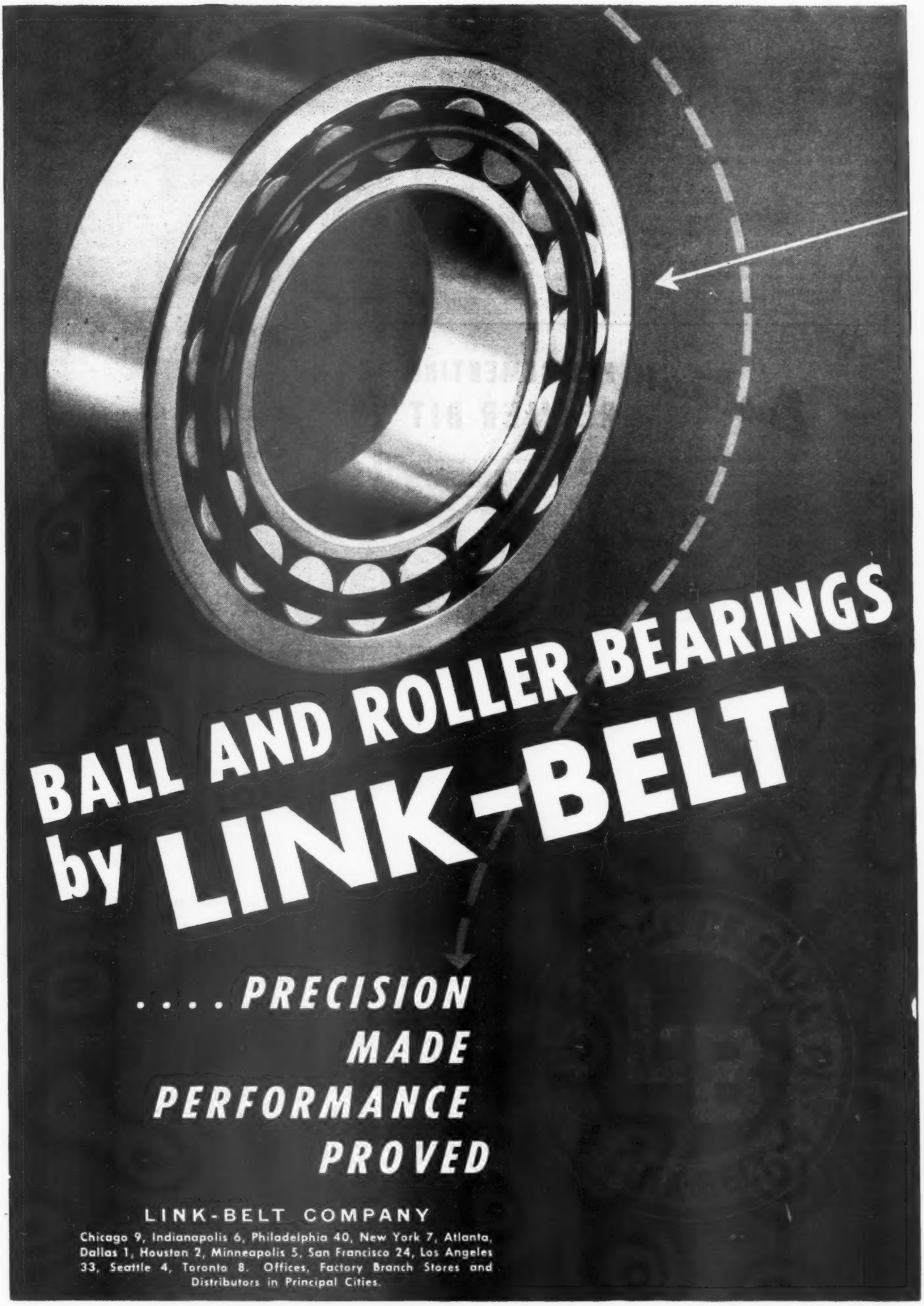
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Chicago 9, Indianapolis 6, Philadelphia 40, New York 7, Atlanta, Dallas 1, Houston 2, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

Acquires Ross stock

Purchase of The A. H. Ross Company, manufacturers of packaging machinery, by Rockwell Manufacturing Company, Pittsburgh, has been announced by Colonel Willard F. Rockwell, chairman and president.

A. H. Ross, president and principal stockholder of the Ross company, will become vice president and general manager of the packaging machinery division of Rockwell, but the company will continue to operate under the name of A. H. Ross Company and maintain its plant in Ludlow, Kentucky.

Rockwell Manufacturing Company is headed by Colonel Willard F. Rockwell, who is also chairman of the board of Detroit Timken Axle Company and Standard Steel Spring Company. It was through the latter company that Colonel Rockwell recently bid $75,000,000 for the Pullman Company. During the war Colonel Rockwell served as director of production of the United States Maritime Commission, as a member of the executive committee of Army and Navy Munitions Board, and on the Requirements Committee of WPB.

Prior to acquisition of the Ross concern, Rockwell Manufacturing Company's business was divided among the manufacture of meters, valves, regulators, and machine tools. Five companies were acquired by the company in 1945.

Plans call for a considerable expansion of production in the Ludlow plant. The principals, in commenting on the transaction defined the acquisition by Rockwell as being a definitely constructive move to increase steady employment in the Cincinnati area.

Eastman PRE-CEMENTING REAMER BIT

The Eastman Pre-Cementing Reamer Bit simultaneously scrapes and washes the section of the hole to be cemented. Then, after withdrawing the center plug of the tool with a wire line overshot, cement may immediately be pumped through the practically full-hole opening in the conventional manner.

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OIL WELL SURVEY COMPANY

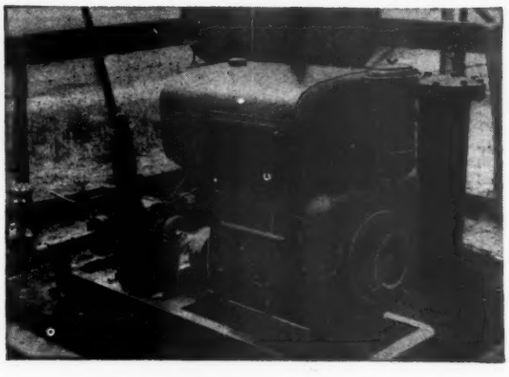
LONG BEACH • DENVER • DALLAS

CONTROLLED DIRECTIONAL DRILLING BY OIL WELL SURVEY SERVICE

Another Specialized Service Application . . . .

of

WISCONSIN Air-Cooled ENGINES in the Oil Industry



This Model VE4 Wisconsin V-type, 4-cylinder Power Unit installation, furnished by Harley Sales Company as one of their Standard Units for specialized services to the oil industry, is direct-connected to a National Transit Rotary Pump, delivering high grade distillate at 175 lbs. discharge pressure. The wire on the Unit is an automatic device which shuts down the engine after a predetermined time.

Today, more and more Wisconsin Heavy-Duty Air-Cooled Engines are being used in a wide range of service applications where extreme dependability and freedom from frequent servicing attention are important considerations. Consult Harley Sales Company regarding your power and equipment requirements.

WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN

World's Largest Builders of Heavy Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.

510 Atlas Building, Tulsa, Oklahoma

M & M Building, Houston, Texas

Oil field distributors for Wisconsin Engines and all types of utility units.

Franks representative

L. R. Page has been appointed Franks Manufacturing Corporation representative in the states of Arkansas, Louisiana, Mississippi, Alabama, Georgia, and Florida, according to an announcement by Carl White, Jr., president.

L. R. Page

Page's headquarters will be at Jackson, Mississippi, at 3539 Hawthorne Drive.

After graduating from Princeton with a B. S. degree in science, and after a two-year term in World War I in the navy, Page moved to Tulsa in 1920, going to work as a roustabout for the Olean Petroleum Company in the Bristow field. He was later chief scout for the firm in Kansas and Oklahoma. Later he organized his own drilling company and oil company.

E. J. vanDyk appointed

E. J. vanDyk brings a well-rounded engineering knowledge of all phases of oil drilling to bear upon his new job as petroleum industry field engineer and district manager of sales for the Detroit Diesel Engine Division of the General Motor Corporation. vanDyk's appointment, announced by Arch F. Campbell, manager of Detroit Diesel petroleum industry sales, is to the district that includes Oklahoma, Kansas and Illinois.

E. J. vanDyk

vanDyk is a mechanical engineering graduate of Wayne University, Detroit, Michigan, Class of 1936. His first employment was with the Surface Combustion Company of Toledo, Ohio, a subsidiary of Cities Service. He served as an engineer with the Detroit City Gas Company before joining General Motors in 1939.

vanDyk will make his headquarters at Tulsa, Oklahoma, and will work out of the General Motors petroleum industry sales office in the Philtower Building.

C-R-C opens branch

With the opening recently of a sales and service branch in Tulsa, Oklahoma, Crutcher-Rolfs-Cummings, pipe line equipment manufacturers and suppliers, has nearly doubled its facilities to the Mid-Continent area, it is announced. Shop facilities in the Houston plant also have been expanded in the last six months.

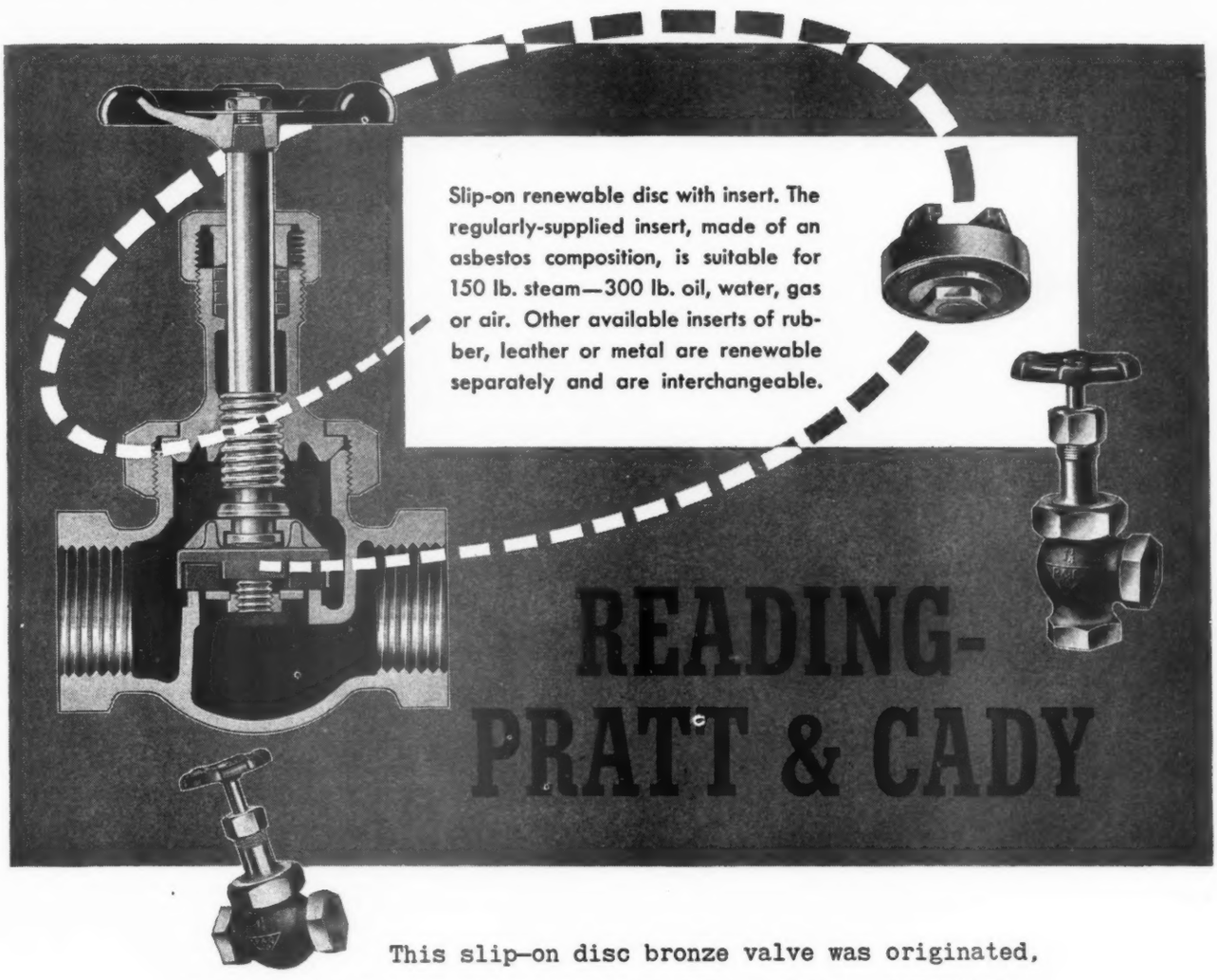
Grover Swartz, W. H. "Bo" Bardsley, and J. S. Roberts will work out of the new Crutcher-Rolfs-Cummings Tulsa branch.

Swartz will be in charge of ditching machines, shovels, and sales and service. "Bo" Bardsley will be in charge of general pipe line equipment and Roberts will be the field serviceman for the Tulsa area.

Crutcher-Rolfs-Cummings purchased a building at 220 West Archer for the new branch office. The building is being completely remodeled for offices and shops. The Tulsa branch will have a complete line of pipe line construction equipment and parts.

This expansion of C-R-C sales and service facilities is designed to meet the demands and needs of the north Mid-Continent area, it was said.

Dependable··Long-lasting··Versatile
GLOBE and ANGLE Valves


Slip-on renewable disc with insert. The regularly-supplied insert, made of an asbestos composition, is suitable for 150 lb. steam—300 lb. oil, water, gas or air. Other available inserts of rubber, leather or metal are renewable separately and are interchangeable.
READING-
PRATT & CADY

This slip—on disc bronze valve was originated, developed and improved by Reading—Pratt & Cady. Essential to fullest performance are disc guides, cast in the bodies and machined, which extend down to the body seats. This is a versatile valve because a soft disc insert gives a tight closure in a globe type valve, basically a throttling type.

Reading—Pratt & Cady distributors are located in principal cities.

Reading Cast Steel Valves and Fittings • Pratt & Cady Brass and Iron Valves
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ACCO

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READING-PRATT & CADY DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

Tulsa representative

George W. Cocke, former district manager in Oklahoma for Erie Meter Systems, Inc., has joined Bowser, Inc. as representative in the Tulsa, Oklahoma, area, it is announced by Walter M. Harks, sales manager of the Bowser Gasoline Pumps and Petinco Division.

Cocke will handle sales of marketing equipment and Petinco (petroleum inventory control) systems to the major oil companies in that territory under the Bowser Dallas district office, and will make his headquarters in Tulsa at 216 East Archer Street, where both sales and service facilities are maintained for Bowser equipment in eastern Oklahoma.

The new Bowser representative has been a district manager in Oklahoma for Erie Meter Systems for the last 13 years. He is a native of Virginia and a graduate of Virginia Polytechnic Institute.

Purchases tool company

The National Supply Company has announced the purchase of the Waynesburg Tool Company at Waynesburg, Pennsylvania. The company took over on May 1 with Edward L. Hollobough as store manager. The store was originally owned by the Prichard Supply Company, and more lately was operated by Donnelly and Wilson.

Hollobough is one of the old-time oil men in the Pennsylvania and West Virginia fields, and has been connected with the supply business for years. He was originally manager for Prichard Supply, and subsequently manager for Donnelly and Wilson.

AMERICAN ROLLER BEARINGS HEAVY DUTY

When we say *super service*, we mean just that! Because AMERICAN SUPER HEAVY DUTY ROLLER BEARINGS are *specially* built for applications requiring *super* strength . . . *super* performance . . . *super* endurance. They are not just "stock" bearings. Often they are designed to exact specifications for the job they are required to do. Their vital, extra capacity to render continuous 24-hour-a-day performance in the heaviest equipment built, under the most adverse service conditions to be encountered in modern industry, is the reason why, for more than 25 years, AMERICANS have been first choice with manufacturers and designers of heavy industrial and oil country machinery. Once adopted, no manufacturer has ever had to switch from AMERICANS. Write today for complete technical details.

AMERICAN ROLLER BEARING COMPANY
PITTSBURGH PENNSYLVANIA

Pacific Coast Offices: 1718 S. Flower St., Los Angeles, Calif.

AMERICAN
Heavy-Duty ROLLER BEARINGS

Roebling promotions

Announcement is made by John A. Roebling's Sons Company, Trenton, N. J., that Ferdinand W. Roebling 3rd has been appointed vice president in charge of engineering. He succeeds Charles M. Jones, who has become vice president in charge of public and industrial relations. Both men are on the company's board of directors.

Upon his graduation from Princeton University in 1933, Roebling became a member of the engineering staff at Roebling and continued in that capacity until called to active military service in September, 1940. He recently returned to the company after serving with the U. S. Army Engineers for five years, and retains the rank of lieutenant colonel in the Officer Reserve Corps.

F. W. Roebling III C. M. Jones

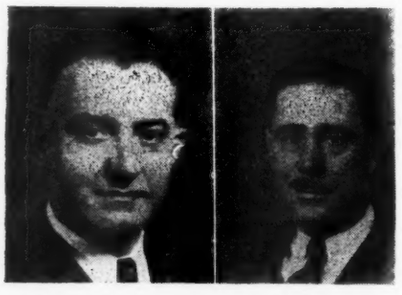
Roebling's appointment provides an interesting sidelight in that he is the third great grandson of the company's founder, John A. Roebling, now actively engaged in management, the others being Charles R. Tyson, president, and Joseph M. Roebling, chairman of the board of directors.

Jones is a graduate of the U. S. Naval Academy, and also attended Massachusetts Institute of Technology. He joined the Roebling staff in 1926, and has held many positions of responsibility within the company. He is widely known in engineering circles, as well as in the field of public and industrial relations, and is a member of the board of directors of both the Trenton and State of New Jersey chambers of commerce.

Factory branch

The Sterling Engine Company, Buffalo, New York, has opened a direct factory branch in San Francisco, it is announced by Addison F. Vars, president of the company. The new factory branch, established to handle expanding business in the Pacific Coast states, will serve the territory west of the Rocky Mountains, and will give the Sterling company a coast-to-coast sales and service organization.

Hans Bohuslav, vice president and director of Sterling's engineering development and research, will be in direct charge of the new factory branch. He will be assisted by Al Hahn, navy commander during the war, who has now joined the Sterling organization.



Hans Bohuslav Al Hahn

At all depths ...on any well

The SEALTITE

controls every operation instantly and accurately

ACCURATE, sensitive and dependable, the Martin-Decker "Sealtite" brings every characteristic of the drilling string into clear sight irrespective of the depth of hole or the kind of formation. Here are some of the reasons why the "Sealtite" is the master drilling control instrument:

FIVE CONTROL UNITS—GIVE FULL DRILLING INFORMATION

The "Sealtite" is a complete drilling control instrument. It incorporates in a single steel case a "Sealtite" temperature-compensated weight indicator, a "Sealtite" mud pump gauge, a torque gauge and tachometer. What's more, it continuously records all variations in weight on bottom, mud pump pressure and drill pipe torque on the one 12" paper chart giving you valuable data for guiding future drilling operations.

UNUSUALLY LARGE CAPACITY—CAPABLE OF HANDLING 20,000-FOOT WELLS

The "Sealtite" Indicator reads directly in thousands of pounds and in points on a big 16" dial face that's indirectly illuminated for easy night reading. A special vernier gauge gives accurate readings for lightweight operations, while the oversize gauge mechanism has sufficient capacity to handle loads greater than any encountered in today's deepest wells.

NO FLUID LEAKS—EASY TO INSTALL

The Martin-Decker "Sealtite" Drilling Control eliminates for all time the problem of fluid leakage. Copper valves and tubing have been replaced with special steel-shielded rubber hose and steel fittings, making the instrument absolutely leak-proof and pressure-tight throughout. It requires no pumping up, no adjustments, and is ready to install the minute it reaches your rig.

Use this modern, comprehensive system for guiding drilling with least expense and most direct results.

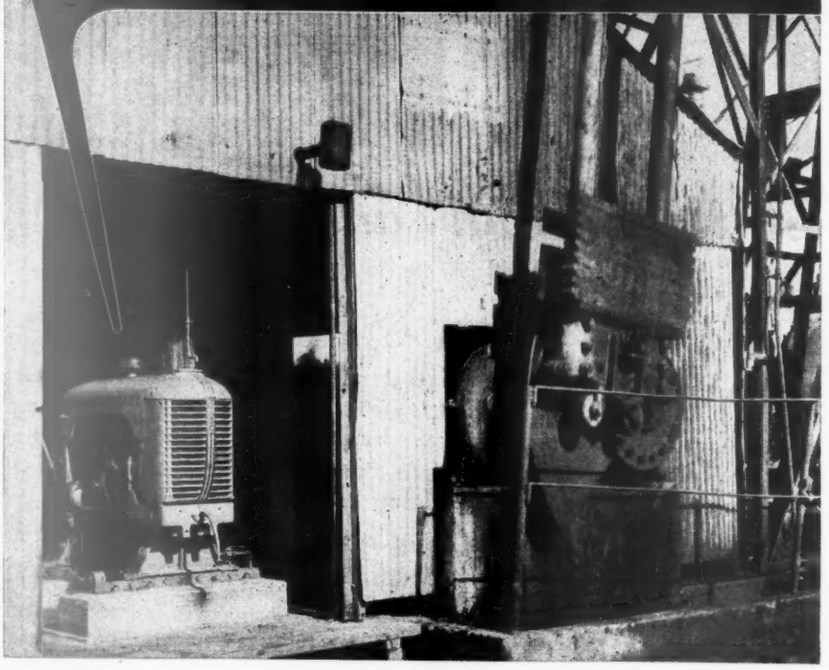
HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY: T. J. CULLEN, BAKERSFIELD, CALIFORNIA
MID-CONTINENT DISTRIBUTOR: REED ROLLER BIT COMPANY, HOUSTON, TEXAS

Long Time No Shutdown



PUMPING WITHOUT PAMPERING

Occasionally we hear about a Case Oilfield Engine that has run non-stop for a year or more, even up to two years. Such exceptional runs reveal the extra ENDURANCE which has earned the respect of oil operators for Case engines.

This endurance reduces the risk of forced shut-down, cuts down the attendance required, makes minor maintenance really minor, puts off the day of major overhaul. Case endurance comes mainly by making every part a bit better than might seem necessary.

Shown above, taking 240 barrels daily from a 4500-foot well in Orange County, California, on a 24-hour, 7-day schedule, is the 42 H.P. Model "DE." Other sizes are the "SE," rated at 28½ H.P. and the 61 H.P. Model "LAE." For full information call the distributor who maintains service in your area. J. I. Case Co., Racine, Wis.

DISTRIBUTORS

Southwest Machinery Co., 1900 Linwood Blvd., Oklahoma City, Tulsa and Hobart, Okla.

Wm. K. Holt Machinery Company, San Antonio, Texas

Southwest Equipment Company, Dallas and Kilgore, Texas

The Gulf Tractor and Equipment Company, 3100 Polk Street, Houston, Texas

CASE OIL FIELD ENGINES

Special engineer

D. O. Bayless, Houston, Texas, has been named special factory service engineer for southwestern United States by Edward Valves, Inc.

D. O. Bayless

Bayless is a graduate electrical engineer of Virginia Military Institute. For the last 4½ years he has served as an officer in the Signal Corps. Prior to his war service he was associated with The Texas Company for a number of years as an engineer assigned to production and drilling projects. He will make his headquarters in Houston, Texas, servicing Edward users throughout the Southwest and assisting Edward sales representatives on specific projects.

Returns to Gardner-Denver

B. P. Spann, well known in publication circles as advertising manager of the Gardner-Denver Company, Quincy, Illinois, has returned to the company after service of more than 38 months in the Navy.

Spann, who has been with the Gardner-Denver Company since 1934, was granted a leave of absence in November, 1942, to enter the Navy. Stationed at the Aviation Supply Office in Philadelphia, he was officer in charge of maintenance and overhaul spare parts for all Navy transport aircraft. His duties took him into nearly all the principal cities of the United States and Canada, and a portion of Alaska. When he was discharged, Spann had the rank of lieutenant commander, having risen from the rank of lieutenant (j.g.).

New California firm

Announcement is made of the formation of the Turbine Bit Company in the ownership of John A. Zublin, petroleum engineer and founder of Universal Engineering Company. He is the well-known inventor of simplex and differential drilling bits.

For the last three years Zublin has been engaged in developing horizontal drilling. With its perfection and completion of field tests, the method is now to be actively exploited by his newly formed Turbine Bit Company.

Operations of horizontal drilling are to be undertaken by various companies.

Turbine Bit Company will operate principally in California and will make horizontal drilling available to oil producing operators with a complete field service that will include engineering, special instruction in the method, and active assistance to drilling crews.

In order to devote his entire time to the operations of horizontal drilling, Zublin has leased his Universal Engineering Company plant at 2369 East 51st Street, Los Angeles, to three of his associates who are successfully carrying on the activities of that well-known concern. Location of Turbine Bit Company has been established at that plant, but will function as a separate organization.

Perry K. Robinson has been placed in charge of services in the field. He will supervise horizontal drilling of drain holes and instruct drillers in the practical application of this new method of drilling to increase oil production. He is fully experienced in the drilling of drain holes, having personally supervised operations in wells already drilled by this method.

David L. Hagmann will be in charge of office and routine work. Telephones are Jefferson 4433 and Jefferson 6151.

The 36-L *Performance Story* Means Profit For You

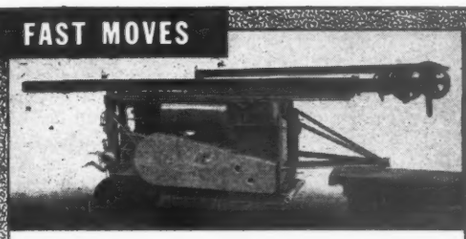
All the feaures that mean profitable spudder performance are combined in the Bucyrus-Erie 36-L, the spudder of tomorrow. Fast, smooth drilling action, complete mobility, ability to handle many jobs, easy operation — these are just a few of the reasons why the 36-L will be outstanding for your work. Look over the features on this page — they'll tell you a story that means profit for you.

K-53

SOUTH MILWAUKEE **BUCYRUS ERIE** WISCONSIN

REPRESENTATIVES IN ALL PRINCIPAL OIL FIELDS

FAST MOVES



Designed for high speed transportation, the 36-L can be moved at speeds of 30 miles per hour and faster with this semi-trailer mounting. Also available is skid-type base for easy skidding to derrick floors, trucks, mudboats.

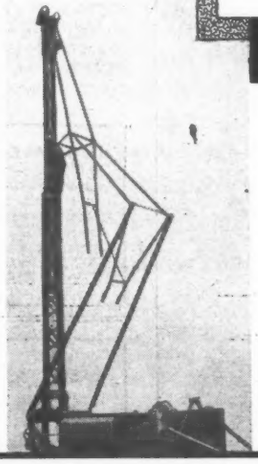
VERSATILITY

Profitable handling of tailing-in, top-to-bottom, clean-out, deepening, swabbing, servicing, and fishing makes the 36-L an all-around profit producer. With the 36-L you're "ready for anything."

SMOOTH ACTION

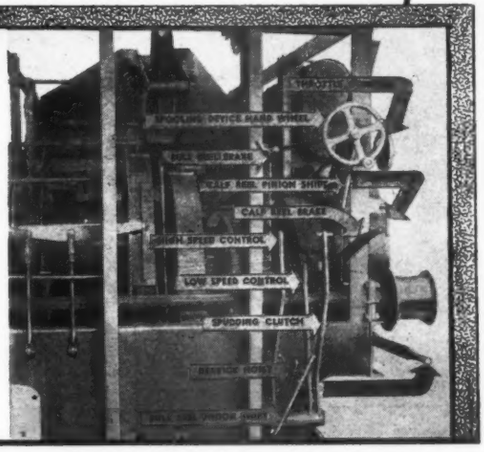
The exclusive rubber shock absorber under the crown sheave keeps drilling smooth with minimum vibration, imparts elasticity and long life to the drilling cable, lets tools strike a sharp, snappy blow for real footage.

QUICK SET-UPS



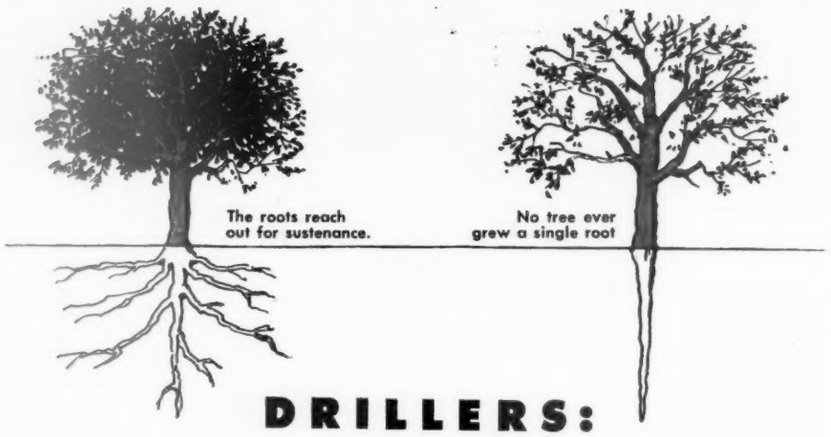
In 20 minutes, two men can easily raise or lower the derrick on a 36-L. A strong latticed steel box structure of the telescoping type, the derrick is extended and raised by a worm-gear driven power winch. Folding tubular braces keep derrick secure.

EASY OPERATION



The convenient arrangement of controls on a Bucyrus-Erie saves time, makes operating easy. All controls are grouped together close to the hole for quick action if trouble starts.

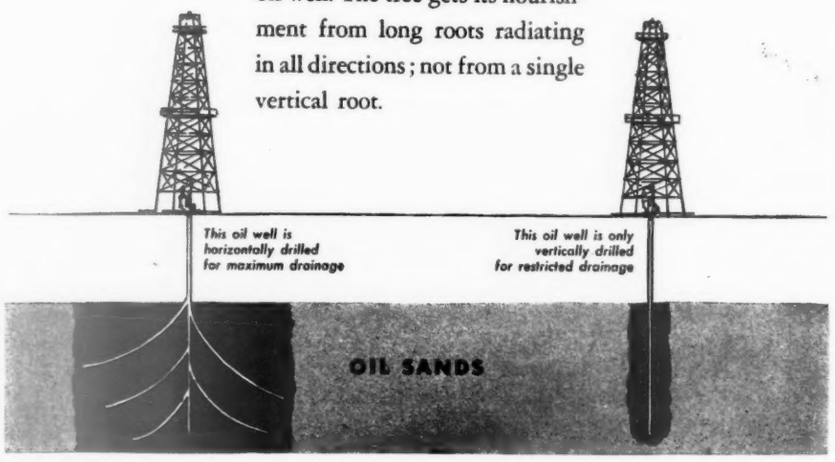
OILFIELD SPUDDERS OF TOMORROW



DRILLERS:

Consider the roots of a tree

Here's a simple lesson in Nature; you can apply it to drilling an oil well. The tree gets its nourishment from long roots radiating in all directions; not from a single vertical root.


This oil well is horizontally drilled for maximum drainage
This oil well is only vertically drilled for restricted drainage
OIL SANDS

Zublin Horizontal Drilling, like the roots of a tree, multiplies the effective area of recovery, reaching far beyond the limits of vertical hole drainage.

We are prepared to increase the production of your old wells by horizontal drilling or insure greatest production from your new wells.

Full details, test records and costs upon request.

Inquiries for Franchises and Manufacturing Rights invited.

TURBINE BIT COMPANY

(Under the ownership of John A. Zublin)

2369 E. 51st St. (Phones: JE. 4433, JE. 6151) Los Angeles 11, Calif.

W. C. Dickerman dies

William Carter Dickerman, a member of the executive committee and of the board of directors of the American Locomotive Company, died in New York City, April 25.

W. C. Dickerman

For 50 years Dickerman was active in the railroad equipment field. Upon graduation from Lehigh University in 1896 he joined the Milton Car Works, Milton, Pennsylvania. There he served successively in the auditing, purchasing, and engineering departments. In 1899 upon formation of the American Car and Foundry Company, of which the Milton Works became a part, he was appointed assistant manager of the Milton district of that company. Transferred to New York in 1900, he became general sales agent until 1905 when he was appointed vice president of American Car and Foundry Company. When America entered World War I, Dickerman took charge of all war production of that company for the United States and Allied Nations. In 1919 he became vice president in charge of operations.

In 1929 Dickerman became president and in 1940 chairman of the American Locomotive Company. After serving through the war years at the request of the board of directors, he resigned as chairman of the board immediately after the war, remaining, however, as a member of the executive committee and of the board.

Dickerman was also a member of the executive committee and of the board of directors of the American Car and Foundry Company. In addition, he was a director of many other leading corporations.

Buys diesel rights

The National Supply Company of Pittsburgh and the Sterling Engine Company of Buffalo have announced that the latter company has purchased the manufacturing and servicing rights to the high-speed diesel engines formerly produced at National's Superior Engine Division, Springfield, Ohio. The announcement was made by A. E. Walker, president of National, and Addison F. Vars, president of Sterling. Production of the engines will be taken over by Sterling as soon as tools and inventory can be transferred from Springfield to Buffalo, Vars said.

Disposal of the company's rights to the high-speed diesels will permit National to expand its facilities for the production of slow-speed, heavy duty diesels suitable for the petroleum industry, larger marine-type installations, stationary power plants, and commercial applications, Walker said.

FOR SALE—Will sell an interest or full patent rights to the Mason Measure Meter described on page 260 of this issue. Or will deal with reliable concern on royalty or bonus basis. Sales good now but potential great. Will use money to help merchandise meter. Safe investment. Address Box 47, % *The Petroleum Engineer*, 700 Irwin-Keasler Bldg., Dallas, Texas.

WANTED: Sales Engineer by oilfield engine distributor. Engineering graduate with thorough knowledge of East Texas oil field. Address Box No. 44, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

MAGNAFLUX

for Inspection of Drill Pipe

Now Featured by

TUBOSCOPE

Drill Pipe Inspection Service

HOUSTON, TEXAS VENTURA, CALIFORNIA

Close collaboration of Magnaflux and Tuboscope engineers has resulted in specially designed, self-propelled, field units for locating potential drill pipe failures, which are caused by fatigue cracks and other defects so small as to be invisible to the naked eye.

FRANCE
Metal Packing
STOPS SHUTDOWNS
CAUSED BY

FRANCE
PHILADELPHIA 35, PA.

REPRESENTATIVES IN PRINCIPAL CITIES

Engineering chairman

The Mississippi Oil and Gas Engineering Committee, at its annual meeting in Jackson, elected Joe T. Goodman of the Gulf Refining Company as general chairman. Goodman succeeds D. V. Carter of the Magnolia Petroleum Company who organized the committee and was general chairman the first year.

W. F. Dalton of the Hunt Oil Company was elected vice chairman, James P. Evans, Jr., secretary-treasurer, and J. D. Davis of the Union Producing Company, chairman of the executive committee.

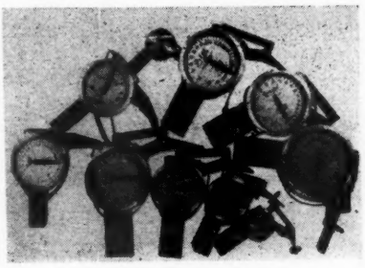
The members of the executive committee elected were W. F. Eiting of The Carter Oil Company; J. T. Reynolds, Sohio Petroleum Company; J. S. Boldrick, Humble Oil and Refining Company; A. S. Rhea, Sun Oil Company; J. C. Phillips, Gulf Refining Company, and D. V. Carter of the Magnolia Petroleum Company.

Admitted as new members in the committee were A. M. Billings of Fair and Billings, A. E. Clapp of Sample and Mucher, and G. W. Pirtle of Hudnall and Pirtle.

J. D. Swartz promoted

J. D. Swartz, district representative for South Chester Tube Company in Tulsa, Oklahoma, has been promoted to manager of sales, Mid-Continent district, including the states of Oklahoma, Kansas, and Illinois. Swartz will continue to make his headquarters in Tulsa with a branch office in Wichita, Kansas. He will also be manager of sales of South Chester Corporation, a recently organized subsidiary, handling specialty products somewhat out of the normal range of the South Chester Tube Company business.

LINE SCALES



10 of the 20 Models we manufacture. 40,000 pounds to 500,000 pounds. A special scale for any job.

With a Line Scale you know the pull on the line, and the weight on the bit in pounds. Accurate, sensitive, rugged and economical.

Line Scales are dependable, even in areas of rapid temperature changes. Repeated tests prove the accuracy of Line Scale readings under all working conditions.

See your supply man, now.

LINE SCALE CO., INC.
Phone 2-1765, 907-11 SE. 29th Street, Box 4245
OKLAHOMA CITY, OKLAHOMA

Made representative

C. C. McDermond has been appointed representative of the welding fittings division of Tube Turns, Inc., in Venezuela and Colombia, South America, it is announced by Jack Green, the firm's sales manager. McDermond and his assistant, C. T. McCoy, make their headquarters in Apartado No. 331, Maracaibo, Venezuela.

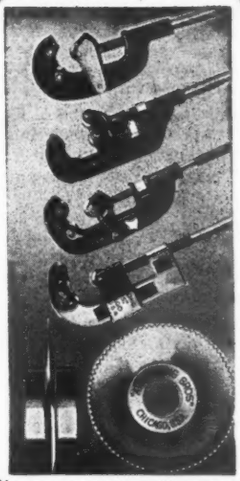
McDermond has long been prominent in the petroleum industry, in both North America and South America. He began his career in 1914 with The Texas Company, as sales representative in western Florida. After World War 1, he was assigned to the company's West Tulsa refinery, where he began acquiring his present broad knowledge of petroleum processes and products. Later he was made manager of sales in Tulsa, then was transferred to Tampico, Mexico, where he held numerous posts in the field. During

C. T. McCoy C. C. McDermond

the peak production period in Mexico, he was the chief scout for The Texas Company, covering all territory south of Tampico to the Tuxpam River. In the latter part of 1923, he was placed in charge of wildcatting operations in the Republic of Panama.

Look for the "Arm-and-Hammer"

ARMSTRONG BROS.



ARMSTRONG BROS. Pipe Cutters are made in all standard types. Each is a quality tool with hardened steel pins and rollers. "Saunders Type"—hardened end of thrust rod bears on inserted hard steel block (double life). In "Drop Forged" and "Combination" types, which take either 1 or 3 wheels, a replaceable hardened steel nut takes up thrust. In the "Barnes" type thrust rod threads through drop forged steel section.
ARMSTRONG BROS. Knife Blade Cutter Wheels (smooth or knurled) have thin penetrating edges that hold their keenness because they are machined from special vanadium tool steel, hardened and oil tempered. Fit all standard-make pipe cutters. . . . *Write for Catalog.*

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. FRANCISCO AVE. • CHICAGO, U.S.A.
Eastern Warehouse & Sales: 199 Lafayette St., New York, N.Y.

The New BOWSER
ESTABLISHED 1885

GAS TRAP . . .

for OIL WELLS

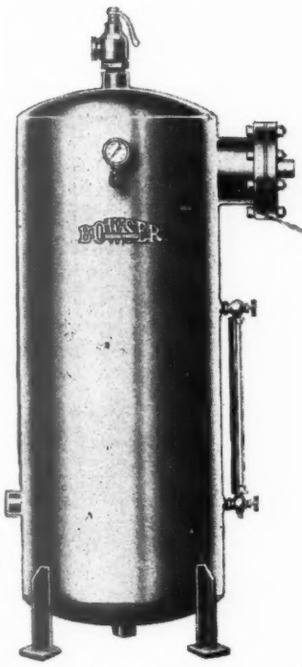
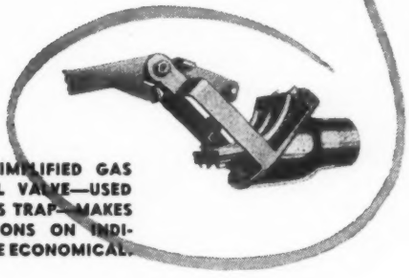


FIG. 426 GAS TRAP

WITH NEW.. SIMPLIFIED GAS AND OIL CONTROL VALVE...

- Eliminates Crude Spill-over into Gas Line
- No Packing Glands
- Operates on Vacuum or Pressure
- No Metal-to-Metal Seats
- No Grinding or Reseating
- Positive Action
- Nothing to Get Out of Order



THIS PATENTED, SIMPLIFIED GAS AND OIL CONTROL VALVE—USED IN THE FIG. 426 GAS TRAP—MAKES METER INSTALLATIONS ON INDIVIDUAL WELLS MORE ECONOMICAL.

The new Bowser Fig. 426 Gas Trap efficiently separates gas from oil in individual well installations or as a central unit for small lease operations.

It is an important part of the complete Bowser Automatic Well-Check System when combined with the Bowser Proportional Sampler and Special Oil Well Meter.

Write today for complete details on the new Bowser Gas Trap.

BOWSER, INC., 1329 Creighton Avenue, Fort Wayne 2, Indiana

LIQUID CONTROL SPECIALISTS SINCE 1885

Thread pipe faster, with less bother, with these smart, handy, little

RIDGID

RATCHET THREADERS

Nos. 00R and 111R

● With one of these efficient and tough little steel-and-malleable threaders at hand, pipe from ⅛" to 1¼" is quickly perfectly threaded. Die heads with heat-treated tool-steel chasers snap in from either side, can't fall out. No special dies are needed for close-to-wall threads. Smooth internal ratchet. No. 00R, ⅛" to 1"; No. 111R, ⅛" to 1¼." Handy, fast, durable—try one and you understand their growing popularity. Ask your Supply House.

Free handy carrier for any group of sizes.

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY • ELYRIA, OHIO, U. S. A.

Davidson to retire

W. D. (Steve) Davidson, director, vice president, and chief engineer of the Emsco Derrick and Equipment Company, retires on the first of June after 23 years' service with that company.

His many friends with Emsco, with the oil industry as a whole, and the oil tool industry in particular, regret to see him leave the active picture, but all are agreed that his retirement is well earned.

W. D. Davidson

Steve is in the best of health and states that he will catch up on his hunting and fishing and take a long time doing it.

He was born in Massachusetts in 1884 and graduated from the Springfield Technical School. His 49 years of continuous active employment has been chronologically as follows: The Duckworth Chain Company of Massachusetts as a mechanic and with Smith and Wesson Gun Shops of Massachusetts as a mechanic. He then became interested in the automobile industry and was employed by the Knox Automobile Company of Massachusetts as an engineer, the Colburn Automobile Company of Denver, Colorado, as chief engineer, the Pope-Hartford Automobile Company of Hartford, Connecticut, the Hudson Automobile Company of Detroit, and the Chalmers Automobile Company of Detroit, serving with each in the capacity of designing engineer.

His oil tool experience began with the Union Tool Company in 1912, where he served 11 years, first as a designing engineer and later as chief draftsman.

In 1923, at the inception of the Emsco Tool Company, he affiliated himself with that organization as chief engineer. The Emsco Tool Company was merged with Emsco Steel Products Company in 1926 and later became the present Emsco Derrick and Equipment Company.

B. S. & B. sold

When A. H. Black, ambitious son of an early day barrel and tank builder, invested his meager savings to start his little Kansas City shop to build wooden tanks for an infant petroleum industry, it is doubtful if his youthful ambition visualized that the venture would some day sell for $7,000,000. Yet, that is the price which A. J. Smith and associates of Kansas City are reported to have paid for Black, Sivalls and Bryson, Inc., whose business they purchased for the A. J. Smith Corporation. The transaction is one of the largest consummated in the Southwest and involved a pioneer oil industry manufacturing concern whose plants, branches, warehouses, sales offices, and field representatives dot the United States and whose products are used in practically every oil producing country in the world.

Arthur J. Smith

Smith, who is president of the A. J. Smith Corporation, and the Smith Engineering Company, becomes the new president and general manager of Black, Sivalls and Bryson, Inc. A. H. Black, founder and president of the pioneer equipment firm, becomes chairman of the board and personal advisor to Smith. Glenn Skinner, vice president, will continue in that capacity. Gwynne Raymond, national authority on oil field engineering and plant production expert, will continue as chief engineer.

"There will be no other changes in officers, management, or policies," Smith announced, "but we will improve and enlarge the line of B.S.&B. equipment to better serve the oil industry of the world."

Administrative headquarters of B.S.&B. will be moved from Oklahoma City to Kansas from where Smith will direct the company's affairs; however, offices in both cities will be greatly expanded as will the sales force. The company's unusual research laboratory will be maintained and expanded for the creation and designing of new products.

One of the oldest and largest midwestern concerns manufacturing oil field equipment, Black, Sivalls and Bryson, Inc., specializes in equipment for the production, pipe line, and refining branches of the oil industry. Its manufacturing plants, branch plants, warehouses, sales and export offices constitute a network of facilities covering the oil industry of the United States, Canada and foreign countries.

The company also makes machinery for the fabrication and welding of steel plates and sheets. Its personnel in plants, offices, and sales force totals 2000 employes.

With its principal manufacturing plants in Oklahoma City and Kansas City, B.S.&B. produces welded and bolted steel tanks and wooden tanks, pressure vessels and oil and gas separators, heaters, treaters, chemical feeders, and valves. They also specialize in safety heads and other field specialties and mechanical equipment.

A. J. Smith, the new president and general manager of B.S.&B., is widely known in the petroleum industry, especially in the refining division. President of the Smith Engineering Company, he is a pro-

fessional engineer and executive. He has a broad background in the manufacture and design of oil field and refining equipment and is intimately acquainted with the problems of the petroleum industry.

A graduate of the University of Kansas, Smith is credited with the development of many present-day methods of petroleum refining. He is a pioneer in refractionation and has patented inventions in the fields of petroleum and metallurgy.

Beginning 53 years ago, in 1893, the story of A. H. Black's business venture provides an interesting story. His small wood tank factory for the manufacture of oil field storage tanks was continued as a one-man industry for several years. Forty-six years ago, James Sivalls became his partner and later the organization was expanded to include Black's brother, the late Edward F. Black, and W. F. Bryson. About 1909, Glenn Skinner entered the company's employ. In 1917, the corporation was set up to operate the vastly expanded operations of the original partnership.

Two members of the old B.S.&B. official family have survived—A. H. Black, an original partner and founder, and Skinner, for many years vice president with headquarters in Oklahoma City. The company's personnel includes one of the largest groups of engineers, metallurgists, technicians, and plant production experts. The staff also includes many veterans among their branch plant and office managers and sales department.

President Oronite Chemical

George L. Parkhurst has been elected to the presidency of Oronite Chemical Company, subsidiary of Standard of California.

He succeeds R. G. Smith, who will continue with Oronite as a member of the board of directors.

G. L. Parkhurst

Parkhurst formerly was vice president in charge of products and processes. During the war he served with the Petroleum Administration for War as assistant director of refining and later as contract executive. In these capacities he was responsible for plant approvals, contracts, and prices in connection with the 100-octane aviation gasoline program. Prior to the war, Parkhurst was with Standard Oil Company (Indiana) for many years and was active in chemical circles in the Chicago area and elsewhere.

The new president has an educational background combining chemical engineering and law. After graduating in chemical engineering from the Illinois Institute of Technology in 1927, he continued with graduate work in chemistry for three years. After four years study at law, he received his J. D. Degree in 1934 at DePaul University.

Bowser appointments

Robert L. Ledbetter has been appointed supervisor of oil field equipment sales with headquarters in Dallas, Texas, according to an announcement made by Fred C. Farmer, manager, meter sales division, Bowser, Inc., Fort Wayne, Indiana. Prior to his association with Bowser, Ledbetter was a petroleum and meter engineer in Mid-Continent and Gulf Coast oil fields for more than 15 years.

Carlos E. Crawford, who recently joined the Bowser organization, has assigned to the company full patent rights on a new, simplified gas trap valve for oil wells. With more than 25 years of extensive experience in oil field production operations, he will ably assist Ledbetter in the sale of oil field equipment with headquarters in Wichita Falls, Texas.

Other representatives who will work with Ledbetter are: R. K. Franklin, Houston, Texas; C. G. Rose, Oklahoma City, Oklahoma; L. E. Pietzker, Dallas, Texas; E. O. Johnson, St. Louis, Missouri, and F. C. Enz, Evansville, Indiana.

A.A.P.G. 1947 meeting to California

Winding up a four-day scientific and technical meeting at the Stevens Hotel in Chicago, the American Association of Petroleum Geologists accepted the California delegation's invitation to hold the 1947 annual meeting in Los Angeles.

The last annual meeting of the group to be held in Los Angeles was in March, 1937, and was staged at the Biltmore Hotel. The annual meeting is attended by geologists from all parts of the United States.

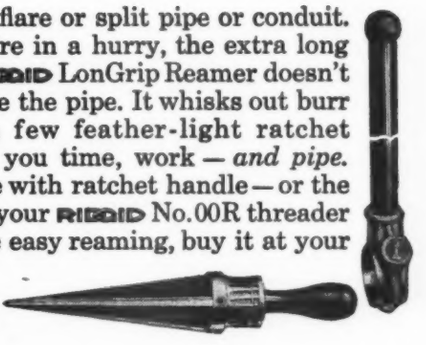
S.A.E. summer meeting

Realistic survey of engineering requirements for future development of automotive transportation and industrial applications of war-developed techniques will feature the program of the summer meetings to be held by the Society of Automotive Engineers at French Lick Springs Hotel, French Lick, Indiana, June 2 to 7.

S.A.E. General Manager John A. C. Warner, announcing the tentative program of the first S.A.E. summer meeting to be held since before the war, explained that 20 morning, afternoon, and evening sessions have been scheduled and that the Golden Jubilee of the automobile additionally will be observed.

With this extra-long-taper RIDGID you ream pipe more easily ..quickly.. safely...

● It won't thin, flare or split pipe or conduit. Even when you're in a hurry, the extra long taper of your RIDGID LonGrip Reamer doesn't gouge or damage the pipe. It whisks out burr cleanly with a few feather-light ratchet strokes, saving you time, work — *and pipe.* Comes complete with ratchet handle — or the reamer unit fits your RIDGID No. 00R threader handle. For safe easy reaming, buy it at your Supply House.



Reamer unit fits No. 00R ratchet threader handle.

RIDGID

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Oil Base, Inc.
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A. G. A. program

A splendid program that will be of great value and interest to technical men throughout the gas industry has been arranged by the gas production and chemical committees of the technical section of the American Gas Association for their joint conference at the Hotel Pennsylvania, New York, on June 3, 4 and 5. An attendance of 500 is expected at this first major postwar conference of production and chemical members of the industry.

Dr. C. W. Wilson, Consolidated Gas Electric Light and Power Company of Baltimore, chairman of the chemical committee, will preside at the morning session on June 3. His program of speakers includes Everett J. Boothby and H. Carl Wolf, president and managing director, respectively, of the American Gas Association. Papers on enriching oils, coal production, water gas set capacity and tar dehydration will be delivered by able speakers.

The first afternoon session will be conducted by R. VanVliet, New York and Richmond Gas Company, chairman of the gas production committee, and will feature a symposium on liquefied petroleum gases, presented by experts in this fast growing field. European gasification processes will be outlined by Captain E. S. Pettyjohn, director of the Institute of Gas Technology. Dr. Gauger of Pennsylvania State College will give a paper on resins.

Hudson W. Reed, vice president of the AGA and chairman of the manufactured gas department, will preside at the morning session on Tuesday. The association's mixed gas research program will be described by W. R. Fraser, Michigan Consolidated Gas Company, vice chairman of the chemical committee. P. T. Dashiell, Philadelphia Gas Works Company, chairman of the gas production research committee, of the manufactured gas department, will report on gas production research. Papers at the Tuesday morning session will cover organic sulphur, flash pulverization, reforming, and catalysts. Four off-the-record luncheon conferences will be conducted on Tuesday, discussing subjects of particular interest.

A sound slide film will be shown at the morning session on Wednesday, followed by papers on blending properties of volatile coals and underground structure corrosion. Reports of several sub-committees will be presented on Wednesday, at both morning and afternoon sessions.

Heads Anchor Petroleum

The board of directors of the Anchor Petroleum Company, Tulsa, Oklahoma, recently elevated William A. Baden, vice president, to the presidency.

William A. Baden

Baden at 37 becomes one of the youngest major executives in the oil industry. He was one of the four founders of the company in 1940.

A second major personnel change saw J. S. Feroe, assistant to the vice president in charge of sales of the Hanlon-Buchanan Company, named to head Anchor's natural gasoline sales department. Feroe, also a young man, is 36, and like Baden, is widely known in oil circles.

In 1933 Baden became connected with the Warren Petroleum Corporation after graduation from the University of Tulsa. He left in 1940 to form, together with Paul R. Smith, L. F. Rooney, and B. B. Blair, the Anchor Petroleum Company.

A.P.I. Eastern meet

Program for the spring meeting of the American Petroleum Institute's division of production June 13 and 14 at the William Penn hotel, Pittsburgh, will center about war-born improvements in drilling and secondary recovery methods.

Virgil Bowyer of Pittsburgh, chairman of the Eastern District of the API division of production, outlined this theme for the program and commented, "Every effort will be made to insure a program that will be useful, instructive, and well worth anyone's attendance, especially those interested in oil and gas production."

Wartime conditions caused cancellation of the 1945 session and plans are going forward to make the June 13-14 gathering a victory meeting, according to S. M. Vockel of Dun-Mar Oil Company, Pittsburgh, a member of one of the committees on arrangements. Hotel reservations should be made early, he said.

Adds to line

The Joslyn Manufacturing and Supply Company, Fort Wayne, Indiana, announces the addition of stainless steel channels to its regular lines of stainless steel ingots, billets, bars, and shapes. The new product was developed as a companion item to the company's stainless steel angles and has broad application in metal fabricating.

The channels are produced hot-rolled, annealed and pickled in A.I.S.I. Types 302, 304, and 316. Sizes are from ¾ in. by ⅜ in. by ⅛ in. to 2½ in. by ⅝ in. by ¼ in. in any length desired.

Book Reviews

● **Manual of Uniform Accounting Practices** *and* **Costing Guide** *(2 volumes). Published by American Association of Oilwell Drilling Contractors. Price:* Manual, *$6.00;* Costing Guide, *$4.00.*

The American Association of Oilwell Drilling Contractors has published and distributed to its contractor members the *Manual of Uniform Accounting Practices,* prepared by its accounting committee, and designed for the use of the drilling contractor. The methods and practices recommended in the manual were selected by the committee after long and careful study of many splendid systems, as being those best suited to the needs of the drilling industry.

This book is the first complete work on accounting to be released in which the principal emphasis is placed on accounting for the drilling of oil and gas wells. Previous oil accounting books have treated the drilling of wells more as a necessary adjunct of producing operations than as a separate and distinctive business. The association manual fills this gap in accounting literature by centering attention on accounting for the true cost of drilling oil wells.

As a companion volume to the accounting manual, the accounting committee, with the help of supply and service companies, has prepared a *Costing Guide,* in which is listed, in alphabetical order, every item of supply material and repair and replacement parts to which a reference can be found.

● **Inflammability of Natural Gas: Effect of Pressure Upon the Limits,** *by G. W. Jones and R. E. Kennedy. Published by U. S. Bureau of Mines.*

This pamphlet has been published by the Federal Bureau of Mines because of its interest in safety in the mining and allied industries. The results of an investigation dealing with the explosibility of various types of combustible atmospheres and explosion hazards of natural gases are given attention in the pamphlet.

● **Lessons in Arc Welding** *Second Edition. Published by The Lincoln Electric Company, Cleveland, Ohio. Pages, 176. Price, $0.50.*

A collection of 61 lessons in arc welding has been made with 200 photos and illustrations to supplement the text. It is a revised and up-to-date printing of the second edition to assist both new and experienced welders and all persons interested or concerned with the subject of arc welding.

"Lessons in Arc Welding" sets forth in simple language the practical instruction based on the experiences of Arthur Madson, head instructor in the Lincoln Arc Welding School. It explains the fundamentals of this method of joining metals by the fusion principle and incorporates a wealth of new information such as how to apply the latest types of electrodes and welding techniques developed during the war years.

● **Gas Analysis and Testing of Gaseous Materials,** *by V. J. Altieri. Published by The Technical Section of the American Gas Association, 420 Lexington Avenue, New York 17, N. Y. Pages, 560. Price $5.00 to members, $7.50 to non-members.*

A revision of the Gas Chemists' Handbook was intended for this volume but new subjects constitute about three-fourths of the text, resulting in a comprehensive book for dry gases and those containing varying amounts of liquids and solids. V. J. Altieri, who was assigned to revise the volume, is chief chemist of Eastern Gas and Fuel Associates, Boston.

The table of contents discloses chapters on kinds of materials, processes, properties and compositions of gases, measurement of quantity and flow, selection of method of sampling, operations, calculations of gas analyses, tests and facilities showing usefulness of gas analyses, and testing of materials and processes in the gas phase. The volume is profusely illustrated and thoroughly indexed.

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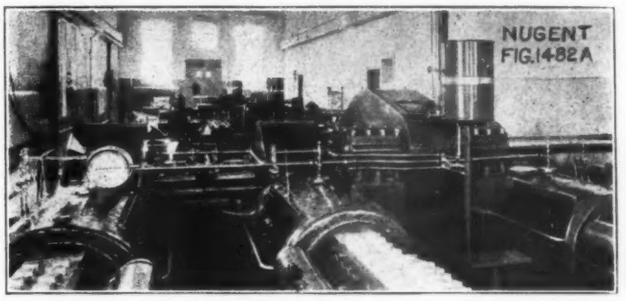

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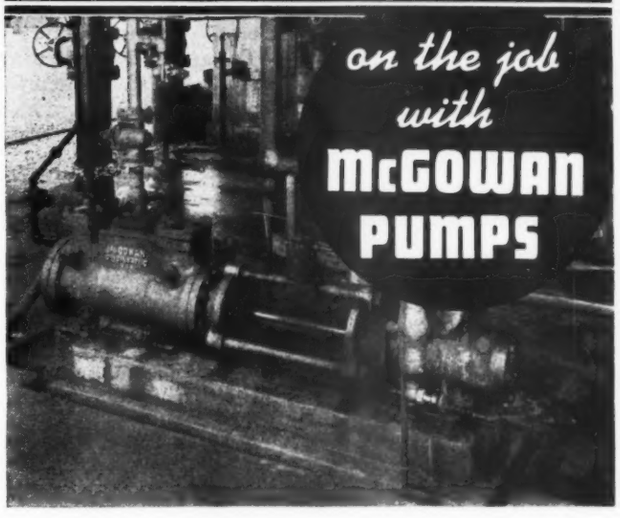

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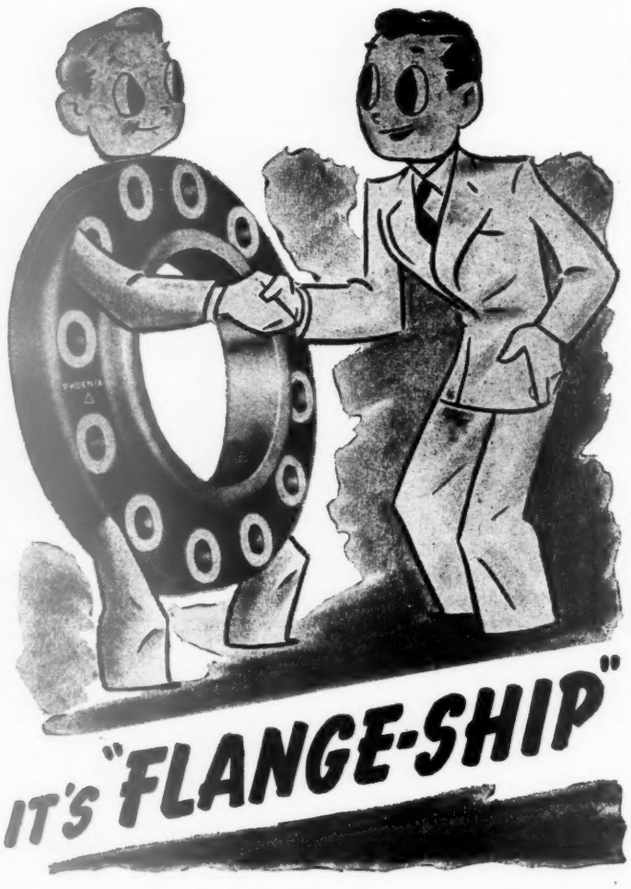

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Pacific Personalities

Once in the dim past we held the distinguished post of chief gauger for a western oil company, and as such we pretty well had the run of the California producing areas. From the orange groves and beaches of the Los Angeles Basin to the sandy fastnesses of the San Joaquin Valley we wandered hither and yon, and we know every terrestrial undulation in this vast expanse as a mother knows her child. Up in Maricopa, not far from the site of the Lakeview gusher, lived one of the outstanding citizens of the region—Charley Woods, better known as "Dusty". His nickname was derived from the fact, according to his kidders, that he was the driest dry hole driller in the San Joaquin Valley. Charley always contended that whatever a man did, he should try to do better than anyone else, and it is said that some of his completions were so arid that the rotary mud had to be extracted from the hole with fishing tools.

In those days Earl Cater was an ambitious young salesman in Taft, and Tom Hickey was a popular lad up in Coalinga who was getting along very well with the aid of an Irish brogue and a good business head. Whiskey Row still flourished in Coalinga, and the gals danced nightly in a honkytonk in the neighborhood of Belridge. The biggest business next to oil was the operation of punch boards and slot machines, and tarantulas, scorpions, and centipedes scared the female help at the boarding houses almost as badly as the oil men did. It wasn't uncommon then for a group of oil workers to stake their endorsed pay checks on a roll of the dice or the draw of a card, the winner picking up the lot and going south or north, depending on his taste, for an orgy the details of which have no place in a respectable publication of this sort. Company boarding houses were gathering places for an interesting assortment of characters, who relayed all pertinent information to the next station along the line. Many an executive has taken what he thought was a secret trip over the territory, only to find that very remotest camp was apprised not alone of his coming, but also of the probable date of his arrival.

•

Over on the coast, according to Bill Farrand, the drilling crew on an Orcutt well—this was also in the stone age—found the going very simple. Day by day, without the slightest trouble, the bit churned its way at the same rate, and there was never any consequential variation in the drilling report. It was all so consistent and uniform that the graveyard driller, a chunky lad named Red McCarthy, was eventually able to predict what progress he would make on his tour. Inspired by this foreordination, he began to make out the drilling reports in advance, send them to Los Angeles, and then with his crew repair to the local pool hall for an evening of elevating diversion. On one occasion while the boys were busy trying to pocket the pay balls, the rig burned down. When they discovered this on their return, the ingenious Red promptly wired headquarters at Los Angeles and asked them to take 12 ft. off the drilling report.

•

Now, coming up to the present time, we understand that Herb Eggleston, the General Petroleum Corporation refining expert, is still convinced that he is the saw player par excellence of the California Petroleum Industry. He and Cy Rubel, another virtuoso of the wailing wood cutter, once engaged in a sonata duel to determine who was the champ. In the middle of the contest, one Frank Morgan appeared from nowhere with an extremely rusty instrument and an entirely new technique. Despite the low character of the Morgan rendition, he was given the highest number of decibels by a large and enthusiastic audience, and ran out an easy winner. Neither Herb nor Cy have ever been satisfied with that contest and have longed for an opportunity to wipe out the stigma of defeat. Some promoter ought to make a cleanup staging a reenactment of the contest. In the meantime, it has nothing to do with the subject under discussion, but with so many saws being diverted into musical channels, maybe we have found the reason for the housing shortage.

•

Diverging slightly here, it is interesting to learn that Ned Brown of Brown Drilling Company, erstwhile president of the Pacific Coast chapter of the American Association of Oilwell Drilling Contractors, didn't always have to dig down for a living. There was a time, and not too long ago, when Ned really wore the big mitt, and besides telling the pitchers what to do, sometimes told the umpires where to go. Ned used to be catcher for the San Francisco Seals—and, having seen him perform behind the plate a time or two in the dining room

of the University Club, we can well imagine that he was one of the leading catchers of his day.

•

Bill Stevenson, who has recently taken charge of industrial relations for Union Oil Company, has been about everything that a man could possibly be in a refinery from utilities inspector to manager. For 21 years he has been occupied in the company's largest refineries at Los Angles and Oleum, rising to the highest post in each, and doing it all in such a manner that he has made a host of friends on the way. Bill is a sort of bashful appearing chap, but that doesn't mean a thing. He has had a wealth of experience in the handling of equipment and people, and by the boys down the line, he is termed "a good joe," so we are certainly wishing him the mosta of the besta as he takes over his new responsibilities. Incidentally, Bill is a keen student of Western and particularly California history. We are told by one of his cronies that he is more interested in early settlers than the credit department.

•

Wherewith we intrude a word about that well known Scotch refiner—and we don't mean that he refines Scotch—Allan Calderwood. When we were a mere child, living in the land of the haggis, we spent many delightful hours on the banks of a stream named the Calder, and many a romp have we romped in the Calder Woods hard by. Which merely shows that the world is a small place after all, or something to that effect. Anyway, Allan is now manager of Shell's Wilmington-Dominguez Refinery. No longer does he have heather between his toes, but we understand he still has a soft spot in his heart for old Caledonia. Our operatives tell us that in his spare moments, if any, when he isn't trying to understand Robbie Burns, he can be inveigled into a game of cribbage at which he is a master. Another of his hobbies is labor relations, and he says he would rather deal with a group of employes anytime than with a deck of sticky cards.

•

While we are in Shell territory, it is only fair that we mention Ike Hemphill, the presiding genius of the Martinez refinery. Here is one of the best golfers who ever shot a birdie out of season. There may be absolutely no truth in the story but we have been told fairly reliably than on a recent outing he had the misfortune to land deep in a sand trap. After four or five unsuccessful efforts to oust the obstinate pill, he spat on his hands and said, grimly, "I'm gonna stay here until I get that thing back where it belongs." At this, the caddy piped up," I guess I better get you another boy, mister—this is my bath night."

•

Speaking of golf, there is a terrific donnybrook now in the making between Standard El Segundo employes and those at Richmond. It appears that one of these fine days, some 75 to 100 divot lofters from each refinery are due to meet in Fresno and indulge in a niblick battle. This tremendous joust is certain to create incalculable havoc, and all local meteorologists have been warned to stand by their seismographs. There seems to be little doubt that the earth is in for an unprecedented beating as the North and the South battle to determine whether the delectable atmosphere of the Carquinez Strait or the rich ozone of the El Segundo coastline is best for developing the belting brawn of which golfers are made. One of the participants in the forthcoming feud recently shot a hole in one—hour, which is at least feud for reflection.

•

George Simkins, personnel manager for Standard of California at El Segundo, is in the process of setting some sort of a record, which will take a lot of beating. George has been painting his house for more than a year, and at last reports had the deal pretty well started. So slow has been the progress on this particular job that local republicans have all concluded it is a government project. On the other hand, under the supervision of C. G. Gillespie, the $2,500,000 sulphur-dioxide plant at El Segundo is coming along very rapidly and is due for completion before very long.

New headquarters for A.S.T.M.

The American Society for Testing Materials, which for a number of years has had its headquarters at 260 South Broad Street, Philadelphia, Pennsylvania, is occupying its permanent headquarters building at 1916 Race St., Philadelphia. This building, which was purchased and remodeled through contributions made by many of the companies and individuals active in the Society's work, provides much needed additional space that is required by the expansion of the Society's staff.

Traffic manager

Announcement is made by C. H. Morse, III, vice president of Fairbanks, Morse and Company, of the assignment of Perry G. Jefferson as traffic manager of the company, to replace Joseph W. Elliott, who recently retired after service of 23 years with Fairbanks-Morse.

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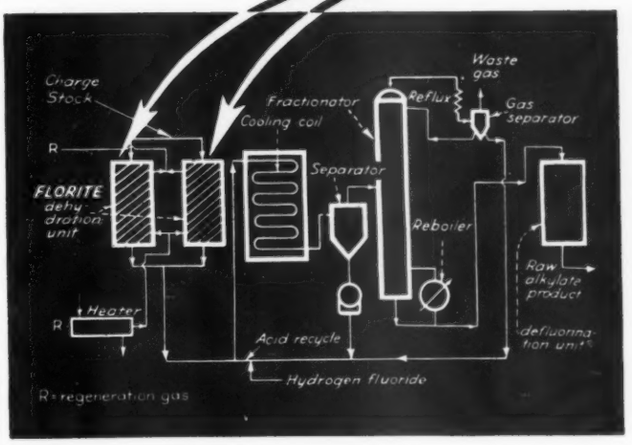

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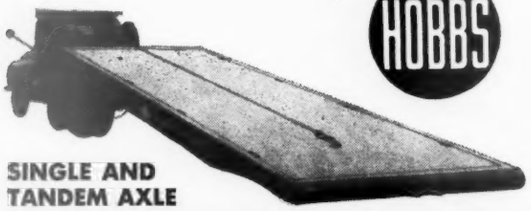

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Trailer front is lowered by winch, forming easy-grade ramp (see photo at top). Truck backed against rear of trailer. Load pulled on with winch or moved on under own power.

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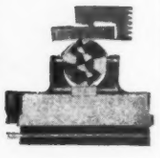

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ROCKFORD CLUTCHES

New Roebling appointments

The appointment of Fred J. Maple as manager of exhibits is announced by E. C. Low, vice president in charge of sales, John A. Roebling's Sons Company, Trenton, New Jersey. Maple, who was formerly manager of advertising, has long been active in this field and is a member of the board of directors, Exhibitors Advisory Council, Inc. Due to the postwar expansion of this medium, he will devote his entire time to this new department.

Albert Neroni

The appointment of Albert Neroni to succeed Maple as manager of advertising is also announced. Neroni, who attended Columbia University and is a graduate of the University of Alabama, brings to Roebling a fine background both in industrial advertising and in sales development. He is widely known in advertising circles, having formerly been assistant manager of advertising for Anaconda Wire and Cable Company, Inc.

Inspect award

K. W. Davis (left), president of Mid-Continent Supply Company of Fort Worth, and Victor LeMay, the company's new advertising director, inspect a Certificate of Award of the Army Commendation Ribbon given LeMay for Meritorious Service as Aide-de-Camp to Major General Richard Donovan, Commanding General of the Eighth Service Command.

Before entry into the Army in 1942, he was well known as an advertising executive in the Southwest and was active in sales promotion and advertising circles. He has just been appointed advertising director for Mid-Continent Supply Company, and in this new position, he will direct both national and export advertising for this oil field supply firm.

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THE METAL WARE CORP. TWO RIVERS, WISCONSIN

New York office moved

Effective as of May 1, the New York office of Sterling Engine Company, formerly at 900 Chrysler Building, has been removed to 401 Fourth Avenue, New York 16, New York.

In its new quarters the Sterling Engine Company will have a large showroom facing Fourth Avenue wherein will be exhibited Sterling marine and industrial engines.

New Cooper general manager

Fred E. Cooper, manufacturer and distributor of Allis-Chalmers well-servicing equipment and power units to the oil industry, announces appointment of Harold E. Cooper as general manager of the organization. This appointment was announced on April 29 at the main office and plant in Tulsa, Oklahoma.

H. E. Cooper

Harold Cooper has been associated with the organization for the last 14 years, beginning as a field salesman in 1932. In 1936 he became eastern division manager. In 1937 he became foreign sales representative and for the next few years visited most of the world's producing oil fields.

In 1943 he was transferred to the Tulsa office in charge of machinery sales, which position he filled until the new appointment.

Changes in executive personnel

Lee C. Moore and Company, Inc., Pittsburgh, Pennsylvania, announces the appointment of Norman F. Rohrkaste as vice president. Rohrkaste assumes executive affairs of the company in addition to his duties as secretary-treasurer, and continues to be in the Pittsburgh office. He has been with the company since 1920.

Homer J. Woolslayer has been appointed vice president charged with the general management of all company oil country activities.

N. F. Rohrkaste H. J. Woolslayer Newton Chapin, Jr.

Woolslayer has been with the company since 1923 and has served as chief engineer since 1941. His headquarters will continue to be in Tulsa.

Newton Chapin, Jr., has been named manager of the industrial division of the company in Pittsburgh. This division is devoted entirely to the development and manufacturing of equipment other than for the oil industry.

Lee C. Moore and Company, Inc., also announces the appointment of A. B. Dunham as sales representative at Wichita Falls, Texas, replacing Charles Geddes, resigned.

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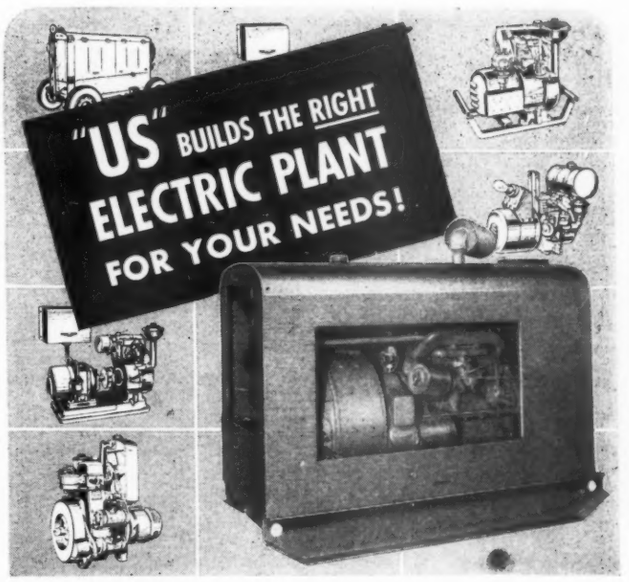

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The Cavins DEPTHOMETER is a simple, compact, direct-reading device that obsoletes "stringing-in" and gives you accurate measurements in very little more time than it takes to make a trip with your bailer. Comes in a handy carrying case (weighs only 17 pounds)—readily taken to any well—put on the line in a few seconds—priced to pay for itself quickly.—Write for illustrated folder.
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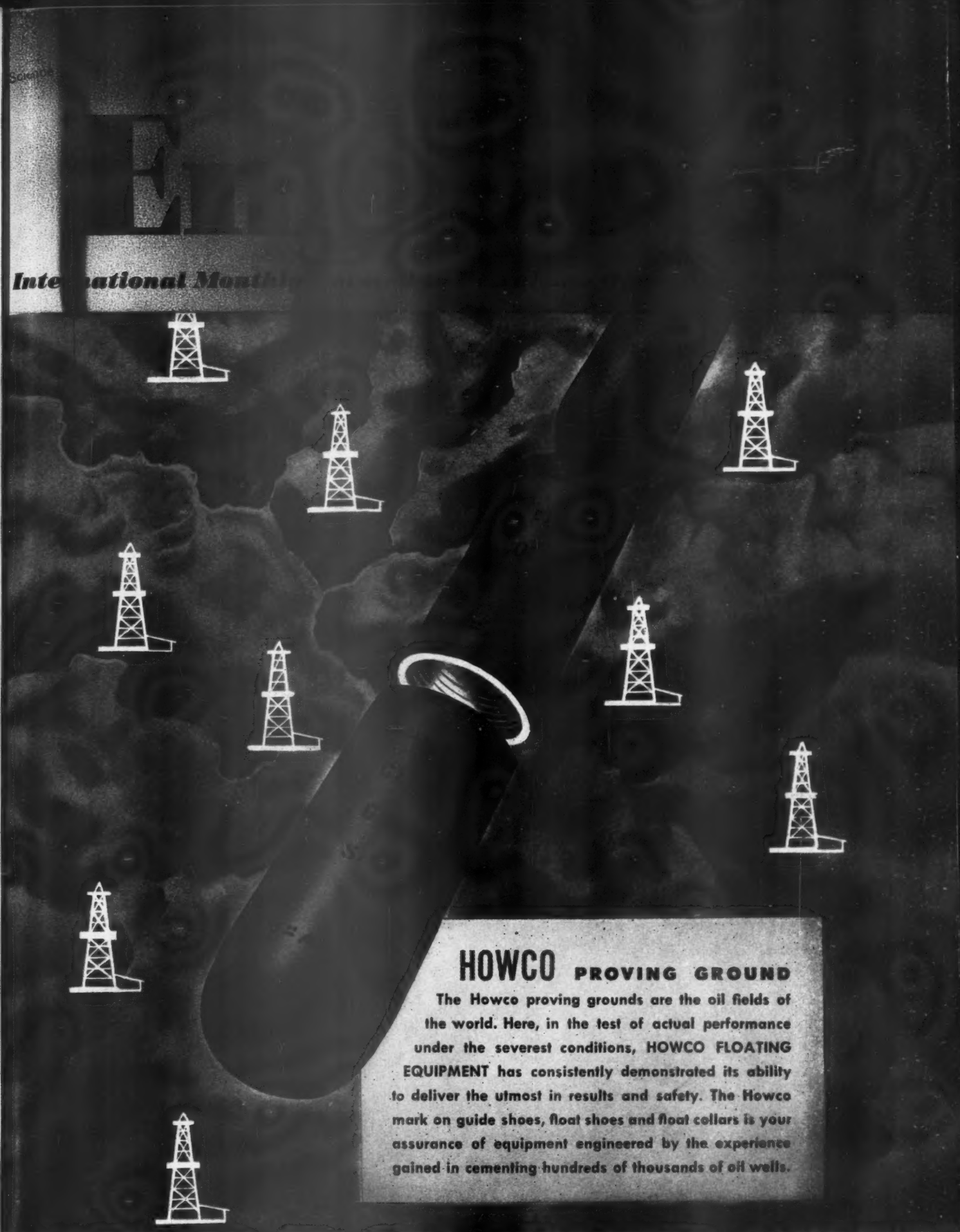
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